International Journal of Ecotoxicology and Ecobiology
2024, Vol. 9, No. 4, pp. 112-121
https://doi.org/10.11648/j.ijee.20240904.11

Research Article

Status and Integrated Management of White Mango Scale on Mango (*Mangifera indica* L.) in Ethiopia: A Review

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Abstract

Mango is attacked by many insect pests which reduce the quality and productivity of the crop. Among the insect pests attacking mango plant, white mango scale is the most devastating insect pest. White mango scale is a new insect pest and a major problem of mango production in Ethiopia. It has been determined that the white mango scale is a new, quickly increasing, and devastating insect pest of mango. It emerged as an upsetting insect pest that now harms mango output, resulting in 50 to 100% losses and forcing the plant out of production in the majority of Ethiopian mango-growing regions. Because there are fewer quarantine restrictions and easier applicability through transport agents, the insect has spread quickly across the country since it was first discovered in 2010. In a short period of time, the insect invaded nearly all of Ethiopia's mango-growing regions, and the country was placed on the list of countries affected with the new white mango scale. Its polyphagous behavior and sucking the plant sap, the insect pest severely harms mango shoots, twigs, leaves, branches, and fruits, which results in significant fruit quality and quantity losses. The insect's hard white scales make it difficult to control with chemical pesticides, in addition to other uncontrolled activities. Although no recognized chemical control methods for the white mango scale are successful, other management strategies for the pest include cultural, biological, chemical, and integrated pest management. White mango scale damage had an impact on the economy, society, environment, and other factors. Therefore, urgently coordinated actions against this uncontrolled white-scale dissemination and the harm it causes in Ethiopia are required.

Keywords

White Mango Scale, Biology, Distribution, Pest Management Option

1. Introduction

One of the most adaptable and popular evergreen fruit crops in tropical and subtropical areas is the mango (Mangifera indica L.) [35]. Due to its superior flavor, wonderful taste, alluring scent, nearly all known vitamins, and several critical minerals, it is referred to be the "king of all fruits". Furthermore, it has a high nutritional value and is a good source of vitamins such vitamins A, C, B1, B2, and D [55], which makes it useful for food and nutritional security, particularly in underdeveloped nations like Ethiopia where obtaining food and nutritional security is challenging.

Mango has been cultivated for a variety of uses, including the production of juices, jams, and other preserves, despite being primarily planted as a desert fruit [29]. In addition, it is cultivated as a medicinal crop and utilized as a leafy vegetable. Mango is also utilized as fuel wood, animal feed, a rich source of nectar for honey bees, building material for canoes and

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Received: 16 February 2023; **Accepted:** 21 July 2023; **Published:** 18 October 2024

furniture, a barrier and windbreak, decoration for town gardens and private homes, and protection from intense sun and rain [6]. Mango kernels have an 8–10% high-quality fat content that can be utilized to make soap and to replace cocoa butter in confections.

Mangoes are highly known in wealthy countries for their great nutritional content and for providing many underdeveloped countries with foreign exchange. The production of mangos accounts for 51% of all tropical fruit produced worldwide [4]. Mangoes are now grown commercially in more than 80 nations and have gained popularity as both fresh fruit and processed goods on the international market in recent years. Mango production worldwide is estimated to be over 46 million tons annually, with India accounting for 40% of global production [54]; however, white mango scale is currently posing a serious threat to agricultural production and productivity.

The Hemipteran scale known as the white mango scale (Aulacaspis tubercularis Newstead) is distinguished by having a piercing and sucking mouth. Due to the lack of a rigid internal quarantine system for the geographical exchange of planting materials, this insect pest may have spread over the world through the movement of planting materials.

The white mango scale has become a destructive insect pest that has spread to most mango-growing regions in the world. It kills the plant and damages mango production, resulting in 50 to 100% economic losses [43]. According to assessment reports, a new, quickly proliferating, and destructive insect pest of mango has been identified as the white mango scale. It causes premature leaf drop, twig and branch death, stunted fruit, distortion, and premature fruit drop, all of which have a significant impact on the quality and quantity of mango yield [38].

In all mango-producing countries around the world, the insect is a major pest. The majority of tropical and subtropical locations that grow mangoes are impacted by the white mango scale. Mango production and productivity are falling alarmingly due to the insect's ability to spread and the less effective management of the white mango scale across all growing zones [43].

Similar to this, there hasn't been enough research done on how the white mango scale was introduced, established, distributed, and controlled in Ethiopia's mango-growing regions. White-mango-scale distribution maps of the world are not reported to include Ethiopia [43]. This shows that there is a knowledge gap on the occurrence, distribution, and severity status of white mangroves between Ethiopia and the rest of the world. Very few reports suggest that the prevalence and insect infestation have gotten worse over time, despite the fact that it hasn't been thoroughly examined. Lack of internal quarantine issues that may stop the spread of the pest into new places is the cause of the problem's expansion [42].

In order to control crop damage caused by the white mango scale, efforts must be made to understand its prevalence and treatment. Abate and Dechassa [1] claim that agro ecology affects the population dynamics of the white mango scale. As a result, not all regions have yet completed the agro ecological-based study to a suitable level. Wale and Melis [57] have noted that variables including temperature, rainfall, wind speed, relative humidity, and daylight hours have an impact on the population dynamics of the white mango scale and its natural enemies.

Numerous studies suggest that integrated pest management techniques are the most effective ways to control white mango scale, despite the fact that they have not been thoroughly tested [17]. The overall goal of this review was to combine the latest research done in Ethiopia with regard to the white mango scale's current situation, its impact on mango production, and management techniques.

2. Literature Review

2.1. Description and Status of White Mango Scale

The white mango scale was first observed in Asia and thereafter spread widely over the world. White mango production is still very difficult nowadays [1]. In the majority of mango-growing regions, the white mango scale is one of the most harmful pests to mango trees. This insect pest damages fruits and their ability to be exported by sucking the plant sap with its mouthparts, causing deformations, defoliation, drying up of young twigs, dieback, poor blossoming, and death of twigs. This is especially true in late cultivars where it leaves visible pink blemishes around the feeding sites [41].). In nurseries, a severe early infestation limits growth. Young mango trees are particularly vulnerable to leaf drop and dead branches in hot, dry [22]. Fruit quality and quantity decreased, mature fruit became smaller, less juicy, rotting, and unfit for commercial use, and infested immature fruit fell [5].

The first instance of white mango scale in Ethiopia was discovered in 2010 at a Green Focus Ethiopia private farm in Loko in the Guto Gida district of Western Ethiopia's East Wollega Zone [25]. Too many others nearby districts, particularly the region's mango production belt, have been affected by the pest's spread [42].

In the 2019–20 cropping season, some 1,666,040 homeowners worked to produce mangos on 16,363.5 hectares of land, accounting for 12.5% of the country's total fruit production [11]. However, it was produced on 19,497.92 hectare during the 2018-19 crop year; mango yields are decreased by 16.08% and 6.09 respectively between the 2018-19 and 2019-20 crop years. Mango yields are reduced by 16.08% and 6.09% respectively during the 2018-19 and 2019-20 crop years. There are rumors that the white mango scale can stop the production of mangoes. Despite a variety of alternative management strategies, quarantine control continues to be the best method for preventing the spread of the white mango scale [46]. Numerous studies have shown that the most efficient strategy to control the white mango scale is to use pesticides alongside other integrated pest management strategies. Mango farms in Ethiopia will be unable to produce fruit owing to this insect if its current state is not regulated. Mango cultivation in Ethiopia is reportedly under grave danger, which could eventually result in the end of mango production altogether.

2.2. Distribution of White Mango Scale

The white mango scale occurs widely throughout the tropical and sub-tropical areas of the Americas, Africa, Asia, Australia and the Pacific [52].

Hodges and Harmon [27]. classify the white mango scale's global distribution into various zones, including: Afrotropical: Zimbabwe, Tanzania, Uganda, Zanzibar, Madagascar, Mauritius, Mozambique, Reunion, South Africa, and Ghana; Neotropical: Aruba, Bermuda, Brazil, British Virgin Islands, Colombia, Dominican Republic, Grenada, Guadeloupe, Martinique, Puerto Rico and Venues Island, Saint Croix, Trinidad and Tobago, Trinidad, U.S. Virgin Islands, and Venezuela; Australasian: New Caledonia and Vanuatu (the New Hebrides); Oriental nations include Malaysia, Pakistan, the Philippines, Sri Lanka, Taiwan, Thailand, China (Guangdong) (Kwangtung), Hainan, Sichuan (Szechwan), India, Karnataka, and Indonesia. Palearctic: Italy, China, Japan, Egypt, Iraq, and so on.

Due to bioclimatically favorable conditions, weak regulatory quarantine laws, easy transferability through planting materials, and being carried across locations by birds and other flying animals due to its very small size and the ability of the male adult white mango scale to fly itself for a long distance with the aid of wind, the pest has spread quickly throughout Ethiopia since its establishment in 2010 ([18]. Inadequate agronomic methods also contribute to the prevalence and severity of the white mango scale. Currently, practically all of Ethiopia's mango-growing regions, including Oromia, Amhara, Benishangul Gumuz, Gambella, Tigray, the southern people's nation, and rift valleys, are home to the white mango scale [38].

2.3. Mango Production in Ethiopia

Ethiopia's mango production is still in its beginnings. Mango, on the other hand, is grown throughout the nation, but is most popular in the Rift Valley, as well as in the western and southern portions of the country. Several uncommon types have been created by the national research system. Therefore, the success and wide distribution of this crop will be aided by lessons learned from producing it in other nations [53]. In Ethiopia, mangoes are typically farmed primarily for domestic consumption and local markets, but some newly established modern farms have begun to grow mangoes for both domestic and international markets. Mangoes from Ethiopia are exported to Saudi Arabia, Yemen, Sudan, Djibouti, and the United Arab Emirates [18]. Raj Agro PLC and Upper Awash Agro Industry Enterprise (UAAIE) are two examples of contemporary farms that produce fruit on a comparatively greater scale. Only a small number of businesses in Ethiopia specialize in the production of fruit juices; one such business, which makes mango juice, is located in Sebeta, 24 kilometers southwest of Finfinne/Addis Ababa [18]. Due to poor productivity and quality, it was reported that Ethiopian mango exports were quite minimal.

2.4. Biology of White Mango Scale

An insect with a circular, flat, thin, and wrinkled body is the white mango scale. Exuviae form a dark, prominent median line that is close to the margin and are yellowish-brown in color with a black median ridge. Males are little and white, with nearly parallel sides and a unique tricarinate pattern. On slide-mount, the prosoma is angular; the body is largest at prominent lateral tubercles, almost level with the front spiracles; the posterior spiracles are typically connected to the spiracular pores; and the thorax and head lack gland spines and macro-ducts [51]. The white mango scale has an overall appearance of a recently born nymph that is very little, elongate, oval, and completely devoid of any wax secretion. The crawler then wanders about until it finds a good location to settle on. After settling, tiny, cotton-like wax threads begin to flow and drip from the body, covering the insect entirely with the white filament that is known as the "white cap." The male crawlers congregate in groups of 10 to 80, frequently close to the females; these groupings are noticeable due to the white scale covers [16].

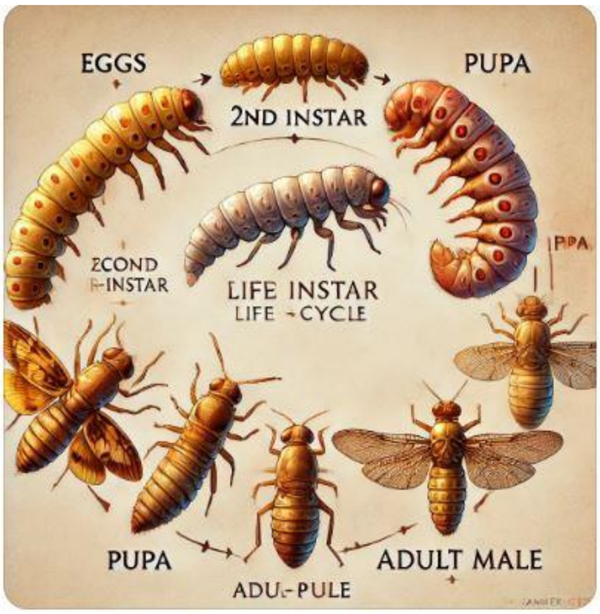

Figure 1. *Life cycles of white mango scale [15].*

Five to six generations of the white mango scale were produced annually [43]. (Figure 1). It was a thermophilic insect because temperature had a significant impact on its ability to regenerate. The female white mango scale is said to lay 80–200 eggs, depending on the temperature at which nymphs emerge after one week. At a maximum daily temperature of 26℃ and a minimum nighttime temperature of 13℃, this insect pest can breed in five to six generations per year. The nymphs consume and reproduce on plant tissues [46].

The post-embryonic growth of the white mango scale includes two female instars (nymph I) and four male instars (nymph I, nymph II, pre-pupal, and pupal) [21]. (Figure 1). The only developmental stages that can move are crawlers and male adults. The crawlers can move and travel across the host plant in search of an appropriate site to settle. Once established, it begins feeding by inserting the stylet into the plant tissue. When feeding, female crawlers randomly settle on leaves, stems, or fruits [15]. While male crawlers establish groups of ten to eighty individuals close to the adult female, female crawlers typically move away from their mother [21]. Approximately 80% of the newly hatched crawlers are typically male in most circumstances. Additionally, the tched crawlers of the armored scale insect are often male. The lengthy, thread-like mouthparts (stylets) of the armored scale insect are six to eight times longer than its body [5].

The white mango scale is polyphagous, eating plants in over thirty seven genera and twenty-three families, including plants in over thirty genera and twenty-three families, twenty-three families, twenty-three families, coconut, coconut, coconut, coconut, ginger, cinnamon, melon, melon, melon, melon, pumpkins and cucumbers. The white mango scale is polyphagous, eating plants in over thirty [21]. By sucking plant fluid with its mouthparts, the insect damages mango shoots, twigs, leaves, branches, and fruits, leading to deformation, defoliation, drying up of young twigs, dieback, poor blooming, and maybe loss of twigs due to toxic substance activity [2]. (Figure 1). Heavy infestations cause fruits to drop too early, and mature fruits are smaller in size, less juicy, rotting, and unsuited for use in commerce [34].

2.5. Ecology of White Mango Scale

Weather conditions are a significant boundary that influences white mango scale dissemination, overflow and their administration. As per Dharmendra et al [16] great atmospheric condition for high bug pervasion ranges between 24-35℃ and relative stickiness 70-95% in the two mango plantations. Abo-Shanab [3] revealed a huge positive connection between everyday mean temperature and relative moistness, and recorded populace thickness of A. tubercularis. Then again, the creator revealed a huge negative connection between wind speed and dew point, and populace thickness of A. tubercularis which might be because of transaction of bug crawlers and early nymphal instars by the breeze to another plants as well as spots.

In a maximum day time temperature of 26℃ and night time minimum of 13℃ white mango scale can produce five to six generations per year [39]. According to Sayed [48], the total population of WMS had maximum value 1006.89 individuals/leaf on June 15th at 15.2-28.4℃ and 56.8% R. H. The lowest level was in mid-December (39.80 individuals / leaf) at 15.0-22.2n℃ and 55.6% R. H. The mean numbers of nymphal, adult female, per sample unit were the highest in mid-March as 343.75 and 147.66, individuals, respectively. The gravid female and prepupae and pupae stages reached their maximum as 129.94 and 694.31 on July 15th and April 15th, respectively. The lowest densities of nymphs and gravid female were 12.33 and 5.33 individuals on mid-December, whereas the least values of adult female and pre-male 3.94 and 15.49 were observed in early September and mid-November, respectively. The total population had maximum value of 1095.65 individuals on April 15th at 12.3-23.8℃ and 57.20% R. H. The lowest total population (58.30 individuals) was observed during Dec. 15th (38.72 individuals/leaf) at 15.2-21.8℃ and 56.3% RH. This pest was higher abundance throughout the period extended from mid-February up to mid-September, while it was lower in abundance from early October up to early February [49].

White mango scale females and males were randomly distributed on leaves, stems, and fruit in mango orchards under organic and conventional management, although males were grouped in colonies of a few individuals to more than 100, which eventually allows them to occupy the entire leaf in depending on the season [56].

2.6. Signs and Symptoms of White Mango Scale

White mango scales are fertilized, and the tiny crawlers that result hatch and travel around until they attach themselves to the area of the plant where they will grow. They then continue to sucker the plant's juice under their armor [26, 28]. A. tubercularis's leaf penetration pattern showed that it can pierce both the cell wall and the lignified xylem materials, leaving behind a reddish substance that was initially thought to be phenolic acid. Slices from infected mango leaves followed the stylet bundle's (SB) course of penetration through the leaf from the point of piercing on the epidermis. The SB altered its orientation multiple times when it entered the spongy mesophyll, including parallel and oblique orientations with reference to the leaf surface [30]. Histological evidence shows that the white mango scale SB explores the interior of mango leaf tissue, including vascular bundles, by modifying its path while maintaining the majority of its track in the mesophyll, after breaching the coriaceous cuticle and epidermis [24]. Mesophyll cells are the main food source for the female, which punctures them without causing them to break. The majority of the SB's intracellular exploration pathway within the leaf tissues is capable of penetrating the lignified cell walls of vascular bundles [30].

Figure 2. *White mango scale around Bahir dar, Zenzelma area.*

Insect scales consuming tender, developing tips can deform foliage. Feeding plants can cause leaves to turn yellow, and watering plants can make them appear strained. Stems and branches may dieback with severe infestations, and sick plants may pass away. Fruit with scales may be disfigured or blemished, particularly if an infestation occurs when the fruit is growing. Few species cause elaborate galls in their host plants. As was already indicated, honeydew frequently encourages the growth of black sooty mold, which can be incredibly unsightly and make plants unsellable. Black sooty mold is superficial and can sometimes be removed with some fungicide applications, but is only recommended after scale insects have been eradicated [35].

2.7. Population Dynamics of White Mango Scale

A study conducted in western Ethiopia found that the population of white mango scale reaches a peak in April and May [19]. The same study also reported that there was a fluctuation in eggs numbers, crawlers and sessile stages across the study months (June 2013 to May 2014). Another survey conducted in southwest Ethiopia also indicates that the insect had distributed in the areas with its peak population density in April and [17]. These studies also found that the prevailing weather conditions in the months significantly influenced the population density.

2.8. Damages and Economic Consequences of White Mango Scale

If the pest is not promptly controlled, the white mango scale could result in the loss of up to 90% to 100% of the economic value of mango production [15]. Fruit production drop between 1.3 and 4.28 kg per tree each year as the number of white mango scale insects per leaf rises [5]. Additionally, 4-5 scales per fruit are enough to degrade the quality of mango fruit [21]. In order to reduce scale effects, mango growers must pay management costs through chemical treatments, which ultimately lead to income inequalities for households.

Ethiopian mango production and expansion are impacted by the white mango scale. Before the appearance of this new insect problem, farmers harvested up to 1000 kg of fruit per tree, according to several studies. However, based on the trees' current state, it's probable that they may or may not bear 200–300 kilograms of fruit per tree because of the severe white mango scale infestation [46]. In addition, insects that taint the fruit and some insects that can travel intact with the fruit contribute to post-harvest losses that are frequent. In the extremely competitive market of today, these damages lead to quality issues. 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.

Mango sales at the national level will be lost. Mango farmers in Ethiopia will so face a danger to their income. Mango, which is similar to mango, is one of the nutrient-rich fruits that locals eat for three to four months. Children were historically the primary consumers of fresh mango fruits from trees; loss of access to these fruits could result in nutritional inadequacies. As a result, the dietary value of mango for local children is high [8].

Furthermore, if the current invasion level persists and continues in the absence of a border, the environmental damage caused by white mango scale would be more severe. Standing mango trees may suffer from drying out if the pest is not controlled. Finally, important mango-growing regions will experience desertification as a result of deforestation and biodiversity loss. As a result, Ethiopia will experience a greater problem with unemployment in the future than it had in the past; many young people will be required to work as day workers in order to survive. Since the issue also has social, environmental, and other effects, it is no longer seen as being just economic [8].

Farmers have not received much institutional support to manage the pest. This generated an environment that was ideal for insects to flourish, leading to a broad infestation that interfered with business operations such as production and marketing. As a result, the insect is now a major problem for everyone involved in working with Ethiopian mango growers. Little is known about this newly arrived pest in Ethiopia. Even the results of the small research investigations weren't widely shared among interested parties. Due to this, the insect was neglected and received little attention from organizations that should have been worried [53].

2.9. Management Options of White Mango Scale

The entire year, the white mango scale hurts mango production. Despite the fact that the population peak is seasonal, this may make the problem difficult to manage. Some researches claim that the white mango scale population peaked between March and May. Therefore, throughout these months, management interventions should be made [15].

Ethiopia is plagued with the white mango scale, which has few or no practical control measures. There are a few different management options, though. The employment of these management strategies is advised in order to keep the population of white-mango scales below the injury threshold. These include integrated pest management, cultural, biological, chemical, and quarantine regulation methods [58].

2.9.1. Cultural Control

Making the environment less conducive to pest development and reproduction is the aim of cultural control. Proper fertilization, trimming, and irrigation preserve plant health, encourage plant resistance to pest attack, and slow the population growth of sap-sucking insects [31].

Cultural control refers to the exploitation of cultural norms to control or eradicate communities affected by the white mange. Pre-harvest fruit bagging, optimal plant spacing, pruning, smoking, clearing vegetation, better fertilizing, and the use of soaps and handmade oils are a few examples [1]. The most major cultural activity that considerably aids in the control of the white mango scale is pruning. It entails getting rid of crooked shoots, aged, dried-out branches, and infested pieces. It increases the tree's exposure to air, which reduces humidity and prevents the white mango scale from hiding and oviposition [53].

Additionally, mulching is a WMS control strategy, especially for young mango trees. White mango scale can be controlled by planting cover crops, especially in mango orchards before fruit production begins. After harvest, plugging orchards exposes adults that are hibernating and lowers infection levels. Pruning effectively gets rid of infected plant tissues and lowers scale [31].

2.9.2. Chemical Control

Scale insects are challenging to control with just pesticides. It is advised to only use contact insecticides when there is a significant percentage of crawlers present if pesticides are to be used to control scale insects. Crawlers are extremely vulnerable to many insecticides, particularly those that include oil. If there are large populations, a systemic product will probably be needed [36].

In Ethiopia, no one insecticide has been registered to control the white mango scale. To manage the white mango scale in Ethiopia, however, certain pesticides are being explored. These include Nimbecidence at 3% EC, Diazinon, Methidathion, and Dimethoate [23]. For the control of the white mango scale, the granular systemic insecticides Spark 250 WG and Thiamethoxam 25% WG (Movento) have shown encouraging results. Folimat, Closer 240 led to a higher decrease in population [12]. Some contact chemicals, however, have an impact on the pest's natural adversaries.

As a result, systemic pesticides and other chemicals that pose less of a threat to the pest's natural enemies should be the focus of chemical screening. Contact chemicals are less successful in integrating with biological control than systemic chemicals. Contact insecticides cannot penetrate the cuticle of the body of the white mango scale [9]. Because of the robust armored outer shell, controlling the white mango scale through contact chemicals is less effective, which makes the scale particularly challenging to handle.

2.9.3. Biological Control

Biological control is the use of natural enemies to limit the harm that noxious organisms (pests) can do to a manageable level [19]. In terms of frequency of use, parasitoids (parasitic wasps and flies), predators (certain insects, spiders, and predatory mites), and diseases (fungi, protozoa, bacteria, and viruses) are the most common natural foes [40]. Parasitoididi Numerous fungi and bacteria can also infect and kill scale insects, although they are less likely to significantly lower populations until they become quite prevalent. Almost all insecticides have a detrimental effect on populations of helpful insects (i.e., predators and parasitoids). Prior to releasing a predator for the first time, it is advised to consult the manufacturer of the biological control agent to ensure that the release is successful. Make sure that enough time has passed if pesticides have been used before releasing beneficial insects [20]. It was decided to introduce an exotic biological control agent and try to establish it in various mango-producing areas because this pest, A. tubercularis, is under good biological control in most other nations that produce mangoes. After being effectively enhanced, released in mango orchards, and well-established, the parasites and predators coexisted together [13, 14]. respectively).

Aspidiotiphagus citrinus (Craw) and Encarsia sp. are parasitoids of A. tubercularis, while Cybocephalus sp., Chrysoperla carnea (Stephens), Chilocorus bipustulatus (L.), and predacious mites are predators of A. tubercularis and Aphytis sp. When it came to the total number of predators found on mango trees, C. sp. had 35.1% dominance, followed by C. carnea (23.5%) and Ch. Bipustulatus (21.4%), with predatory mites having the lowest percentage at 11.8%. Three peaks, estimated to be 0.90, 0.91, and 0.94 individuals per leaf and observed on May 1st, July 1st, and August 15th, respectively, could be seen in the overall mean total population of A. tubercularis predators across two years (2010 and 2011). The study of A. tubercularis parasitoids on infested mango in the presence parasitoids, Aphytis sp. was the common parasitoids represented 40% followed by Encarsia sp., (34%) and A. citrinus (26%).

White mango scales were infested by the larvae of the ladybird beetle Chilocorus sp. (Coleoptera: Coccinellidae), and these larvae were observed feeding on both male and female white mango scales. When feeding, the larvae readily tore through the male mango scale's coat to get to it, but they had to firmly push their heads inward and partially open the female's cover before they could capture and chew it. In each case where the larvae were observed, a colony of white mango scales was also present [19].

2.9.4. Host Plant Resistance

A growing focus is being placed on non-chemical or alternative means of controlling scale insects due to the high prices of chemical pesticides, the challenges associated with their application, and the environmental and groundwater contamination risks they pose. The three categories of plant insect resistance mechanisms are tolerance, antibiosis, and nonpreference [44]. The use of resistant cultivars, such as those that are resistant to the white mango scale, is both practical economically and environmentally safe.

Since "non-preference" refers to the insect, which is inconsistent with the idea that "resistance" is a quality of the plant; the term has since been replaced by "antixenosis" [33]. The plant uses antixenosis as a defense strategy to prevent insect infestation. Although insects may gravitate toward plants in search of food, oviposition places, or refuge, some plant traits may discourage them due to biochemical, morphological, or a combination of both factors. Antixenotic-resistant plants should experience less initial infestation and/or a faster rate of pest emigration than susceptible ones. Contrary to antixenosis, which has a positive impact on an insect's growth, reproduction, and survival, antibiosis is a method through which a colonized plant is resistant. These antibiotic side effects may cause an insect to become smaller or heavier, become more restless, accumulate inadequate food reserves, which may affect the survival of hibernating or aestivating stages, or they may have an indirect effect by increasing the insect's exposure to its natural enemies [50]. The degree to which a plant can withstand an insect infestation without losing strength or lowering agricultural yield is known as plant tolerance.

Beck [7] does not consider that tolerance falls within the definition of resistance. Plant tolerance is usually taken to mean that when two cultivars are equally infested the less tolerant one has a smaller yield. At the plant physiological level the loss of tolerance is due to an abnormally heightened response to infestation, at the epidemiological level tolerance is considered a component of resistance [45].

The degrees of white mango scale infection on mangoes varied across several of the varieties in Kenya's Samuru and Kimani areas. Apple Mango was less infected than Samuru Vandyke. Of all the mango varieties at Kimani, the Kent mango was found to be the most contaminated. Apple mango was one of the cultivars in both locations with the fewest pests [19]. But few researches have examined the field-based tolerance or resistance of diverse host plant species or cultivars to soft scales [10]. Plant genetics, physiology, and biochemistry are expected to work together to give host plant resistance to scale insects [37]. Compared to Tommy Atkins, who was extremely sensitive to fruit flies, the mango varieties Alfa, Espada Stahl, and IAC111 shown field resistance to fruit flies. Contrarily, Espada Stahl and IAC111 had their field resistance disrupted and became as susceptible as Tommy Atkins whereas Alfa retained its field resistance under artificial infestation under cage settings [47].

Insects are particularly drawn to the dense canopy structure of mango plantations, according to Karar [32]. Insects must adapt to changes in leaf morphology in order for leaf size and shape to change in response to insect attack. The invasion of sucking insects on host crops is significantly impacted by the size of the leaves. The small shape and narrower leaf width of the mango varieties Fajri, Sindhri, Malda, Dusehri, and Anwar 14 Retaul finally led to lower mealy bug abundance in these crops than in other genotypes.

2.9.5. Quarantine Regulation

The current management recommendations include performing national bounding inspections, establishing and expanding quarantine facilities, enacting legislation banning the interstate movement of mango fruits and planting materials, expanding the capacity of plant health clinics, and using biorational and suggested soft insecticides [46].

2.9.6. Integrated Management

The white mango scale cannot be controlled by cultural, biological, or chemical means alone. Therefore, during the mango production periods, the integration of various management alternatives is quite important [1]. Cultural activities like repetitive crop management are necessary for crop management techniques like trimming and routinely checking for white mango scale infestations. White mango scale infestation was less common in improved mango types including Apple and Keith mangoes [43]. In addition to cultural control, the management of white mango scale should take into account the use of natural enemies such as Cybocephalus binotatus, Aphytischionaspis, Aphytis mytilaspidis, Encarsia citrine, Chilocorus, Scymnus syriacus, Sukunahikona prapawan, Rhyzobius pulchellus, and Rhyzobius lophanthae [43].

Effective pesticides should be used when a population of white mango scale reaches a level that causes economic harm. After the fifth cycle of applications, Movento and Methidathion 400 EC insecticides were shown to induce up to 90% and 74% mortality of white mango scale, respectively, according to several researchers [42]. After three treatments of the pesticide Folimat 500SL, 90% of the white mango scale had been controlled in another trial by Djirata [18] comparing the effectiveness of two insecticides against the white mango scale.

3. Conclusions

White Mango Scale is a recently discovered, quickly proliferating, and destructive polyphagous insect pest of mango. It can harm many genera and families of mangoes, stunting fruit and causing distortion as well as early leaf and fruit drop. The quantity and quality of mangoes are significantly impacted by these factors. Currently, it is a devastating insect pest that severely reduces mango production, results in large financial losses, and renders the crop unviable in the majority of Ethiopian regions that grow mangoes.

It can have five to six generations every year, and the wind can help the male adult scales fly long distances. Currently, this insect is widely dispersed throughout the majority of Ethiopia's mango-growing regions. The white mango has tough scales that prevent contact insecticides from penetrating its cuticle and reaching its body. As a result, contact chemicals are less effective at controlling the scale, making it more challenging to control.

It is difficult to regulate due to its high rate of reproduction, capacity to spread by the movement of planting materials, and capacity to fly thanks to the wind. These days, we can distribute information more widely in a short amount of time, which has effects on the economy, society, ecology, and other factors. Therefore, the reports currently available indicate that Ethiopia's mango production will be seriously threatened and may perhaps be destroyed in the future absent an immediate concerted and focused effort.

However, appreciable initiations from government offices, scientific communities, and growers were observed to alleviate the series of problems caused by this insect pest. Beside to these efforts, different research activities are underway on the identifications and control systems that have including the cultural management systems (smoking of under mango trees, removing of infested and burnt out mango branches) and screenings of suitable chemical control methods. In general, in order to manage the wide spread of the insect pest, strengthening the internal quarantine regulatory system and focusing on the integrated pest management options are very important options to tackle the problem before it completely spreads to the healthy areas and the mango tree is taken out of production in the country. Therefore, every stakeholder, including scientific communities and government bodies, should strive to control this series of insect pests in the mango-producing areas of the country.

Author Contributions

Zemed Wobale Birhanie is the sole author. The author read and approved the final manuscript.

Conflicts of Interest

The author’s declares that there is no conflict of interest.

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