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Survey of the Distribution and Severity of White Mango Scale in Mango Production in Eastern Ethiopia

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Abstract: Mango production in Ethiopia is harmed by a number of arthropod pests particularly the White Mango Scales (WMS) is major pest of grave concern to mango growers. The main objective of this study was to assess the current status of WMS insect pest in Mango production and farmers' knowledge about the pest in eastern Ethiopia. WMS distribution and severity specifically in the major mango growing areas East Hararghe, Harari regional state, and Dire Dawa were surveyed. The survey result indicated that WMS is distributed across most of the mango growing districts of the surveyed zones with the exception of few areas which were found to be WMS free. A total of forty-seven mango grower fields infested with WMS and 470 mango plant leaf samples within altitudinal gradients ranging from 1166 to 2170 meters above sea level were checked for WMS infestation. Severity and abundance of WMS was highest at Dire Dawa followed by Babile, then Haramaya and Harari sub districts. The comparative means of both male and females' number of WMS showed that the severity was significantly different across the districts (p values <.0001) for number of males, number of females and for both males and females of WMS.

Keywords: Mango, White Mango Scale, Distribution, Severity, Farmers

1. Introduction

In terms of its socio-cultural importance and present level of production, the mango (Mangifera indica L.) is one of the most significant fruits grown in the tropics [1]. Following the banana, it is Ethiopia's second-largest fruit crop [6]. A total of 1,337,049.26 quintals of mango were produced, with a productivity of 68.57 quintals per ha [6]. Ethiopia's primary mango-producing regions include west and east Oromia, Harari, Southern Nations and People's Region (SNNPR), Amhara, Rift Valley and south-western Ethiopia [3, 18]. Due to their high sugar, protein, fat, salt, and vitamin content, many farmers are grow mango trees for consumption as fresh fruit and for use in various drinks as well as a source of revenue and shade [13, 14]. However, a number of arthropod pests such as White mango scales, Fruit fly, mango gall flies, Mango leaf coating, Mites, Mango seed weevil, Mealy bug, Spider mites, Mango tip borer, Termite, Thrips and White flies affect Ethiopia's significant mango output [17, 15]. Among these, growers must effectively manage yield losses brought on by the invasive insect pest, White mango scales (*Aulacaspis tubercularis*; Homoptera: Diaspididae) [17, 15]. The white mango scales distributed in a wide of climates [4]. This insect pest is a tropical insect species that was initially discovered on mangoes in India [4] and may have originated in Asia Borchsenius [5]. It is currently widespread in many countries that produce mangoes and was spread through the transportation of infected plant materials. In Ethiopia white mango scale is first recorded in 2010 in Western Ethiopia East Wollega Zone of Oromia region in green focus Ethiopia private farm at place of loko in Guto gida district [13]. White mango scale is sucking insect pest that causes damage to mangoes by feeding on the plant sap through the leaves, branches and fruits. This feeding behavior of the pest causes defoliation, drying up of young twigs, poor blossoming resulting in a reduction in the commercial value of fruits and their export potential due to conspicuous pink blemishes pink at the feeding sites of the pest. Such economic loss is more pronounced in especially late cultivars. A severe early-stage

infestation in nurseries inhibits growth. During hot, dry weather, young mango trees are especially prone to excessive leaf loss and twig death. white mango scale causes severe damage by pierce cell walls with its stylet bundles and nutrient exploring potential of even the lignified secondary walls of xylem of plant [10]. The severely infected premature fruits drop, and the mature fruits become small in size and contain little amount of juice [17]. White mango scale is infesting mango trees and spreading quickly, causing more damage and having a significant negative impact on farmers' ability to make a living [17]. Post-harvest cleaning and washing cannot completely eliminate scales, and quality control inspectors in the packing house may overlook some fruit that is contaminated [7]. Mango development and production in Ethiopia are similarly impacted by this insect issue. There is a lack of knowledge regarding the introduction, establishment, distribution, and associated severity levels of the white mango scale in the eastern region of Ethiopia. There was little information available because it was new to the eastern part of the country. As a result, the goal of this study was to evaluate the current situation of the White Mango Scale insect pest on mango production and farmers' knowledge of the pest in Eastern Ethiopia.

2. Materials and Methods

To ascertain the distribution and severity of the white mango scale (WMS), this survey was conducted during the 2022 cropping season in eastern Ethiopia, specifically at the major mango production areas of East Hararghe, Harari regional state, and Dire Dawa. The districts of Babile, Sofi, Amir-Nur, Haramaya, and Dire Dawa were specifically chosen as places with high level of mango production. High land, mid land, and low land make up the agroecology of the sample sites. The major rainy season in the sampled locations occurs from June to September. The survey was carried out a total 59 farmer sites spread throughout three Zones, but 47 sites were used for sample collection. Following a categorization of the producers based on the size of the plantation, survey fields from each zone were chosen. Using a hand lens and visual inspection of the upper and lower surfaces of the leaves, it was determined whether there were any white mango scales on the mango leaves in the field. When WMS colonies were present, there was a female surrounded by males, and they were counted. To determine the distribution and extent of damage caused by white mango scale, an average of 10 leaves were collected from each small farmer's site. Ten leaves were chosen at random from each mango tree's top, middle, and bottom parts to count the clusters of white mango scale that developed on the leaves. A total of 470 sample leaves were collected. Interviews with the growers concerning the white mango scale insect problem took place during each sampling.

In total, 94 growers were interviewed about their operations, two growers for each of the 47 sample fields. When and how the WMS insect pest was introduced to the area, its distribution, severity, prevalence, extent of damage, parts of the plant affected more, and the management practices options of the farmers in the past and present situation of the MWS pests were all information that was gathered from sampled mango growers. These growers also provided information about their perspectives on the major constraints to mango production. The result was utilized to determine the pest status at each survey site. The study regions were mapped using GIS software, and geographic information such as the longitude, latitude, and altitude of each sampling location were recorded using GPS. As per the methodology employed by (Fita, 2014; Babege et al., 2017) [9, 2], the gathered sample leaves were transferred to the Haramaya University Agricultural Entomology laboratory in polyethylene bags for the sake of accounting procedures. Using identification guidelines for insects, the identification was made based on the morphological characteristics of the insect pest.

Table 1. *Method of data summary used for determination of WMS severity status.*

Relative frequency of White mango scale occurrence	Severity index	Grades of severity status
0	0	No infestation
1-5	1	Less infestation
6-10	2	High infestation
≥ 11	3	Very high infestation

Relative frequencies of White mango scale occurrence at each site were calculated by the use of formula adopted from Kataria R and Kumar D [11].

$$\text{Relative frequencies of WMS occurrence} = \frac{\text{Number of WMS recorded per mango farm}}{\text{Total number of WMS recorded from survey area}} * 100$$

Data Analysis:

The collected data were subjected to statistical analysis. The severity of the insect pest and its distribution in the study areas were determined by counting of white mango scales on mango leaves. Microsoft office excel was used for the data organization. SAS 9.4 software package was used for population variation between surveyed districts. LSD was used for mean separation at 0.05 significance level.

3. Results: Distribution and Severity of White Mango Scale in Eastern Part of Ethiopia

The survey findings showed that, with the exception of a few regions that were not affected by WMS, White Mango

Scales were distributed throughout the mango-growing districts. Forty-seven fields were infested with this type of pest but level of infestation varied from location to location.

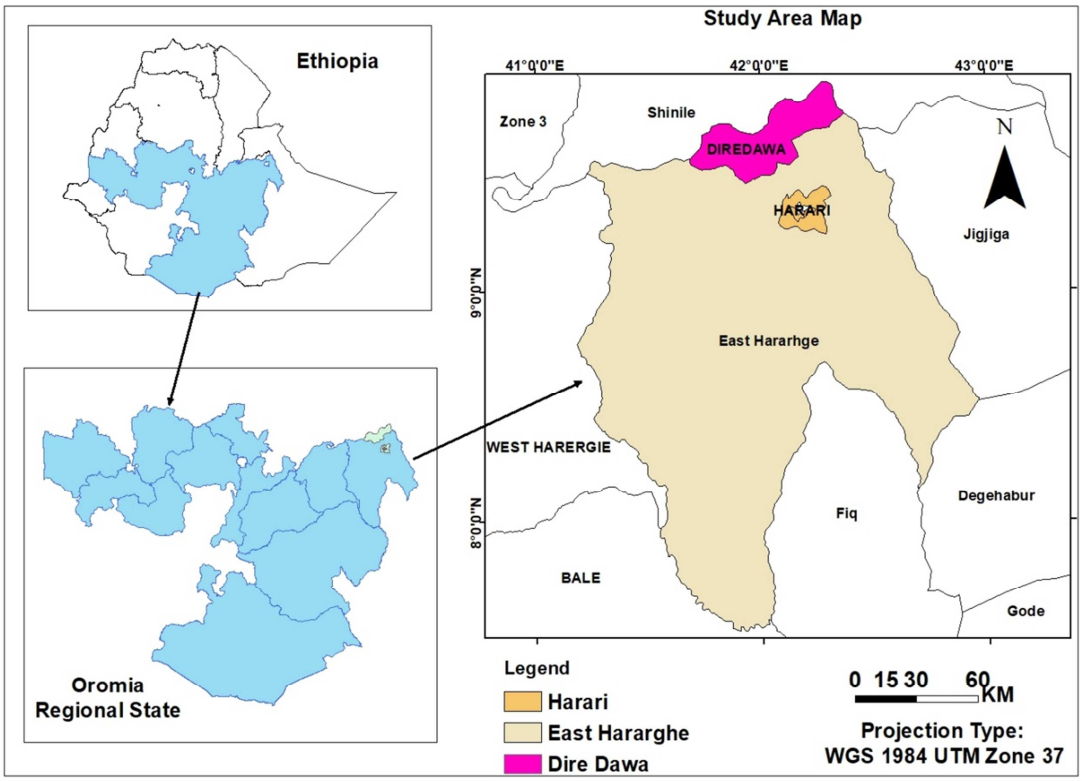

Figure 1. *Survey sites in Harari region, East Hararghe and Dire Dawa zones, eastern Ethiopia.*

Table 2. *White mango scale status across field survey (districts).*

Region	Districts	Altitud e (m.a.s.l) mean	Location		Number of fields observed
			North	East	
Harari	Sofi	1746	09°28.01'	042°15.82'	6
	Harewae	1750	09.25.63'	042°05,98'	3
	Qile	1408	09°24.67'	042°22.69'	4
	Dire Teyara	1801	09°31.61'	042°14.47'	2
	Amir-nur	1800	09°29.54'	041°12.65'	2
	Sheck abdi/Jalane	1636	09°21.07'	042°35.19'	9
	Babile 01	1638	09°21.09'	042°35.17'	2
	Babile 02	1632	09°21.67'	042°36.16'	2
	Ifa	1402	09°23.34'	042°26.43'	3
	Ira guda	1410	09°23.55'	042°26.13'	3
Oromi a	Haramaya 02	2092	09°40.25'	041°98.74'	2
	Adele Keke	2039	09°42.12'	041°94.54'	2
	Dangago	2170	09°45.75'	041°90.80'	4
	Boru	2131	09°45.50'	041°87.28'	3
	Bate	2062	09°42	042°04.	3
	HaramayaUniversity	2043	09°41	042°03.	1
	Jallo balina	1405	09°53.32'	041°87.87'	3
Dire Dawa	Dire Dawa town 03	1215	09°59.19'	041°86.01'	2
	Dire Dawa town 02	1166	09°61.20'	041°84.16'	2
	Dire Dawa town 01	1200	09°63	041°78.	1

Table 2. *Continued.*

Region	adult male of WMS	adult female of WMS	male and female of WMS	Severity index	Severity status
	Mean±SD	Mean±SD	Mean±SD		
Harari	25.5±5.0i	3.5±1.5hi	29.00±5.0k	1	Low infestation
	34.67±6.0h	9.67±3.0h	44.33±6.0i	1	Low infestation
	28.5±4.0i	3.75±2.0hi	33.50±3.0jk	1	Low infestation
	0±0j	0±0i	0.00±0L	0	No infestation
	0±0j	0±0i	0.00±0L	0	No infestation

Region	adult male of WMS	adult female of WMS	male and female of WMS	Severity index	Severity status
	Mean±SD	Mean±SD	Mean±SD		
Oromia	190.89±1.5a	19.78±5.0f	210.67±20.5c	3	Very high infestation
	144.5±4.0c	60±4.5b	204.50±5.0cd	3	Very high infestation
	139.5±2.0c	55±2.0b	194.5±5.5de	3	Very high infestation
	44±4.0g	8.33±4.0gh	52.33±9.0i	1	Low infestation
	26±6.0i	4.67±2.5gi	30.67±6.0k	1	Low infestation
	0±0j	0±0i	0.00±0L	0	No infestation
	0±0j	0±0i	0.00±0L	0	No infestation
	86.5±2.0e	41.25±4.5d	127.75±7.0g	2	High infestation
	68±5.0f	33±3.0e	101.00±12.0h	2	High infestation
	0±0j	0±0i	0.00±0L	0	No infestation
	0±0j	0±0i	0.00±0L	0	No infestation
Dire Dawa	115.67±1.0d	29.67±4.0e	145.33±5.0f	2	High infestation
	115±5.0d	78±4.0a	193.00±3.0e	3	Very high infestation
	193.5±2.0a	50±5.0c	243.50±3.0a	3	Very high infestation
	176±4.5b	50±5.0c	226.00±8.0b	3	Very high infestation
CV%	4.91	14.09	7.57		
LSD (0.05)	5.61	5.21	11.46		
P value	<.0001	<.0001	<.0001		

Means followed by the same letters within Columns are not significantly different at P<.0.05 level of probability by LSD (0.05) comparison.

4. Discussion

A total of 47 mango grower fields with WMS infestation and 470 leaf samples from mango plants were examined for WMS presence along altitudinal gradients between 1166 and 2170 meters above sea level. According to the results of the current survey, which are presented in Table 2 and Figure 2, the pattern of white mango scale insect pest distribution and severity status across each districts eastern Ethiopia were not uniform. The Dire Dawa subdistrict has the greatest levels of white mange scale severity and prevalence, followed by Babile, then Haramaya, and Harari. The severity status and distribution varied, which would suggest the existence of possible factors that have a varying impact on the dispersion of insect pest populations at the local habitat level. In regions that were surveyed, the white mango scale pest was seen to cause varied levels of severity. The Babile and Dire Dawa districts of the surveyed localities had high and very high WMS severity status, the Harari regional state had both low and no infestation, and the Haramaya district had no infestation with the exception of Dangago and Boru kebeles, which had high infestation in the surveyed localities as shown in Table 2 and Figure 2. Additionally, the survey revealed that the severity of the white mango scale infestation ranged from no infestation to severe (Table 2). This observation is supported by Fita, (2014) [9] which reported that there were differences in infestation levels between the study sites in the East and West Wollega Administrative Zones (2014). Additionally, Babege et al. (2017) [2] reported that the distribution of the white mango scale infestation varied among the surveyed districts and seasons. The majority of the high to very high severity statuses that were recorded were found in hot locations at relatively lower altitudes. The comparative means of both male and female white mango scale showed that the severity status was significantly different among the districts p values <.0001 for number of males, females and for both males and females. No infestation was recorded in fields of Dire Teyara (0.0), Amir-nur (0.0), Haramaya town 02 (0.0), Adele keke (0.0), Bate (0.0) and Haramaya University (0.0), lesser infestation was recorded in fields of sofi (29.00±5.0), Harewae (44.33±6.0), Ifa (52.33±9.0), Ira guda (30.67±6.0) and Qile (33.50±3.0). High infestation was recorded in fields of Dangago (127.75±7.0), Boru (101.00±12.0) and Jallo balina (145.33±5.0) and very high infestation was observed in the fields of Shek abdi/Jalane (210.67±20.5), Babile 01 (204.50±5.0), Babile 02 (194.5±5.5), Dire Dawa town 03 (193.00±3.0), Dire Dawa town 02 (Haramaya University field site) (243.50±3.0) and Dire Dawa town 01 (226.00±8.0).

However, due of its widespread dispersal by wind and other material agents, nymphal (crawler) stage may be quickly transported to nearby healthy mango trees if adequate management is not planned for it.

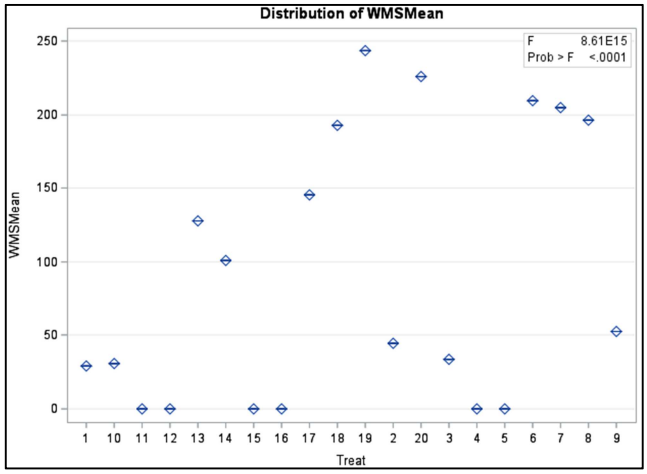

Figure 2. *Distribution of white mango scale across all field survey.*

Treat=represent Districts/Kebele, 1= Sofi, 2= Harewae, 3= Qile, 4= Dire Teyara, 5= Amir-nur, 6= Sheck abdi/Jalane, 7= Babile 01, 8= Babile 02, 9= Ifa, 10= Ira guda, 11= Haramaya

02, 12=Adele Keke, 13= Dangago, 14= Boru, 15= Bate, 16= Haramaya University, 17= Jallo balina, 18=Dire Dawa town 03, 19= Dire Dawa town 02, 20= Dire Dawa town 01.

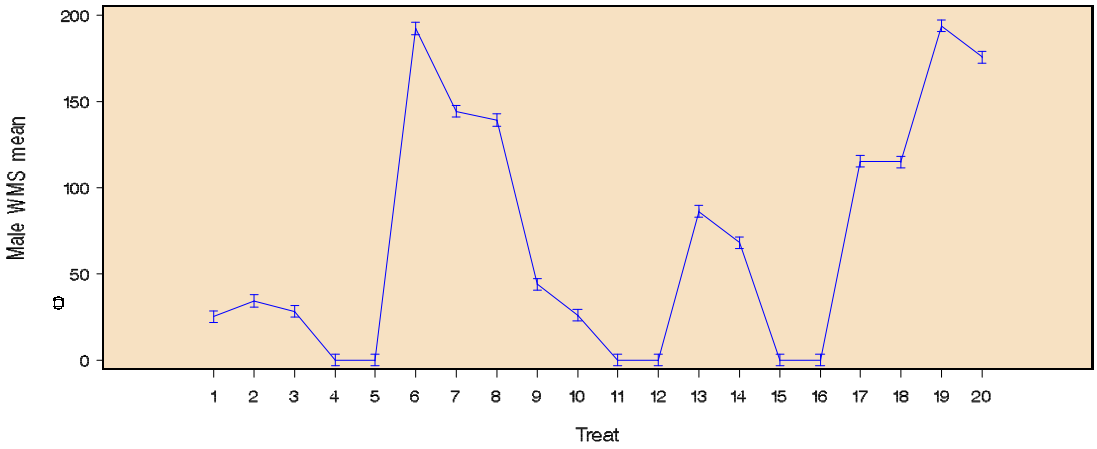

Figure 3. *Distribution of male white mango scale across all field survey.*

Treat=represent Districts/Kebele, 1= Sofi, 2= Harewae, 3= Qile, 4= Dire Teyara, 5= Amir-nur, 6= Sheck abdi/Jalane, 7= Babile 01, 8= Babile 02, 9= Ifa, 10= Ira guda, 11= Haramaya 02, 12= Adele Keke, 13=Dangago, 14= Boru, 15= Bate, 16= Haramaya University, 17= Jallo balina, 18= Dire Dawa town 03, 19=Dire Dawa town 02, 20= Dire Dawa town 01.

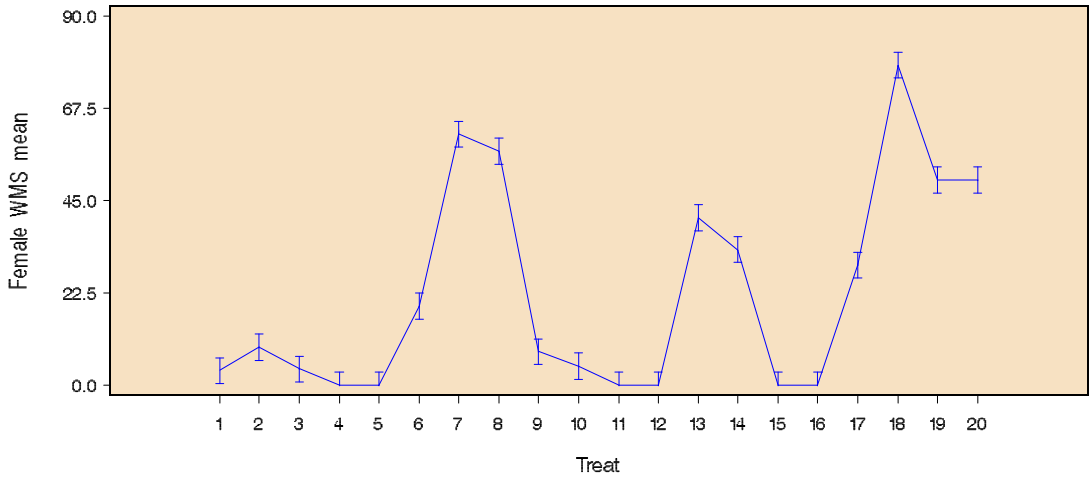

Figure 4. *Distribution of female white mango scale across all field survey.*

Treat=represent Districts/Kebele, 1= Sofi, 2= Harewae, 3= Qile, 4= Dire Teyara, 5= Amir-nur, 6= Sheck abdi/Jalane, 7= Babile 01, 8= Babile 02, 9= Ifa, 10= Ira guda, 11= Haramaya 02, 12= Adele Keke, 13=Dangago, 14= Boru, 15= Bate, 16= Haramaya University, 17= Jallo balina, 18= Dire Dawa town 03, 19=Dire Dawa town 02, 20= Dire Dawa town 01.

Figure 5. *White mango scale insect pest infestation status on mango leaf surface. A; Upper leaf surface infestation. B; Lower leaf surface infestation.*

The white mango scale insect pest infestation status on mango leaf surface was demonstrated to be more abundant on upper leaf surface (Figure 5A) than on lower leaf surface (Figure 5B) in all examined sites where WMS occurs. This research supported the findings of Nabil et al., 2012 [14], on mango in Egypt, which revealed that white mango scale preferred the upper leaf surface compared to the lower one. Additionally, Djirata et al., 2018 [8], and Merkuz et al., 2021 [12], stated that the investigation of white mango scale infestation status on mango leaf surface indicated that it was more abundant on upper than on lower leaf surface in all orchards during the study periods.

4.1. Farmers' Perception About White Mango Scale

Farmers readily responded to the questionnaire since there are several current mango difficulties that they did not disclose, but the harvest of mangoes is far lower than it was. All (100%) of the farmers who responded said they had never experienced this problem in their mango farms and thought it was a new insect pest in the assessed locations. According to Temesgen's (2014) [16] research, the majority of respondents did not know the name or classification of the pest. They do not know how or when the insect was brought to their farm, but because they have only recently noticed the pest's symptoms in mango farms, they believe it to be a new pest.

When the insect attacked and penetrated into the leaves, it produced blotches and whitish materials, which farmers identified as the symptoms of the infestation. This led to the leaves falling to the ground. When the infestation in one tree became so bad, the tree began to die back from the top. The insect infestation was moving from one mango plantation to another so swiftly. Farmers reported that WMS were scarcer during the wet season, and that as the rainy season came to an end, they became more common on mango trees. During the flowering period, insect pests progressively ascended to the top of the trees and then quickly attacked and infested the mango fruit that was still immature. According to their response, young seedlings appear to be more severely attacked than the older local variety trees. When asked if the damage caused by insect pests on their mangoes affected their revenue, virtually all participants (almost 100%) responded that it did since the infestation made the fruit's quantity and quality worse and made it less marketable, which reduced their annual income. Losses also happen during harvest and delivery to the neighborhood market. The information from farmers was consistent with Mohammed et al., (2011) [13] which suggested that the farmers experienced a lot of pre and post-harvest fruit loss due to the white mango scale starting from the first production year.

According to 62 (65.96%) of the responders, the infestation started in the plant's leaves before spreading to the branches and fruits, 21 (22.34%) and 11 (11.70%), respectively (Figure 6).

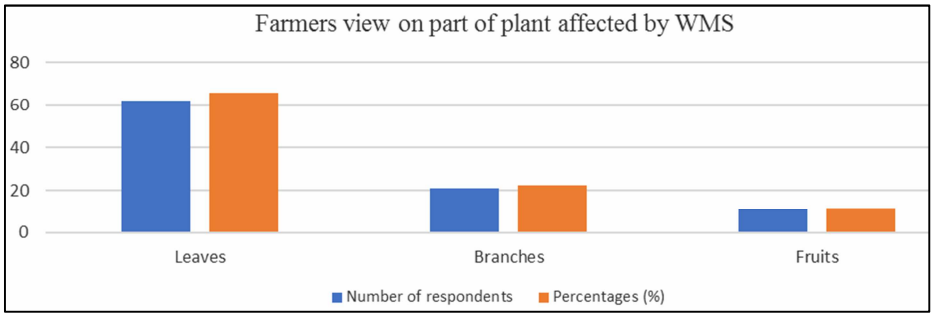

Figure 6. *Respondents response to parts of mango trees get infested first.*

A very small percentage of farmers used cultural pest management measures, such as cutting badly affected branches, but they did not try additional pest control measures like chemicals since the mango plant was too large and difficult to spray pesticides on. In the survey regions, farmers are still looking for opportunities to implement control measures. Growers who were asked whether the controlling measures were effective answered with 13 yes votes (13.83%) and 81 no votes (86.17%).

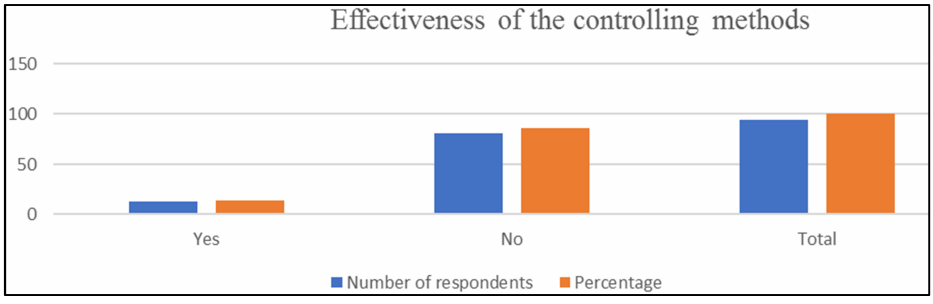

Figure 7. *Effectiveness of the controlling methods growers responded.*

In the study sites, white mango scale infection on mango leaves was widespread. Some of the infected mango leaves were nearly entirely covered by the insect due to the infestation's severity. Heavily infested leaves became brown and wilted (Figure 8).

Figure 8. *White mango scale infestation on mango leaves, branches and fruits from surveyed areas. A; at Sheck abd/ Jalane. B; at Babile town 01. C; at Babile 02. D; at Ifa. E; at Sofi. F; at Ifa. G; at Harawae. H; at Dangago. I; Jallo balina. J; at Dire Dawa.*

4.2. Laboratory Observation

Infected leaves that had been collected were analyzed under a microscope in a laboratory, and the results revealed that at the time, infestations by males were heavier than infestations caused by females. Both young and old trees were affected by the pest, but young trees were more vulnerable to excessive leaf loss and twig death.

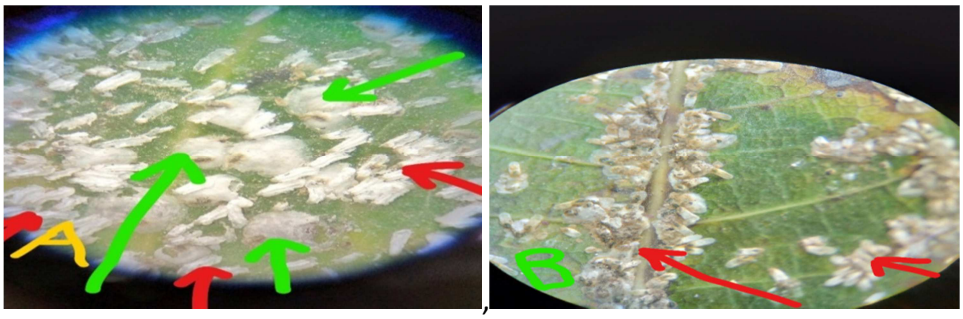

Figure 9. *A. Clustering of male of WMS (red arrow) around female of WMS (green arrow); B. Male and Female of WMS dense at vein of Mango leaf.*

5. Conclusion and Recommendations

White mango scale was discovered in Ethiopia's wollega zone in 2010 at Green Focus Private Farm in the Loko Administrative kebele of the Guto Gida district. Since this initial occurrence, the presence, distribution, and severity of white mango scale have been observed in the mango-producing regions of Babile, Harari, Haramaya, and Dire Dawa in eastern Ethiopia. The distribution of pests, however, differed from place to place. In eastern Ethiopia, where white mango scales are rapidly spreading, farmers who plant mangoes should be given training on how to protect their fruit against infestation. It will be necessary to conduct additional research on the biology and dissemination mechanisms of the pest in relation to agroecology. To control the white mango scale, integrated pest management should be used. It will also be necessary to conduct mass production in the field and search for natural enemies (predators and parasitoids) in the area or in the country of origin.

Conflict of Interest

The authors declare that they have no competing interests.

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