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Distribution and Population Dynamics of the White Mango Scale, Aulacaspis tubercularis in Southwest Ethiopia

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Abstract

The White mango scale (WMS) distribution, population dynamics and severity status was conducted in southwestern part of Ethiopia. Purposive sampling was used to select districts growing mangos. The existence of the WMS was confirmed by visual assessment in the field and using a stereo microscope in the laboratory. The population dynamics of the WMS was studied in two locations in west Welega zone (Didesa Valley and Uke farms) and one location in west shoa zone (Bako tibe district). Leaf samples were collected from the four cardinal directions of the mid canopy of five tagged trees every month for 12 consecutive months. The number of eggs, crawlers, male's colonies and females were recorded using stereo microscope. High to very-high infestations were recorded in all the surveyed areas while exceptionally low populations were observed in some districts of Jimma, Kafa and Ilu-Abba bora and west Welega. Population dynamics of WMS reach the maximum peak in April in Didesa and Green focus sites while at Bako site the population reached its climax in May. The correlation study showed that the populations of the WMS are except maximum temperature positively correlated with weather factors. During study we recorded more WMS population density in south and west directions. Therefore, management interventions should be planned accordingly to coincide with the peak population periods and distribution directionality. This study has indicated that the WMS problem is serious in southwestern Ethiopia..

Keywords: White mango scale; Distribution; Severity status; Population dynamics

Abbrevations: WMS: White Mango Scale; Spp: Species; CV: Coefficient of Variation; LSD: Least Significance Difference; EIAR: Ethiopian Institute of Agricultural Research; SNNP: Sothern Nations Nationalities and Peoples; APPRC: Ambo Plant Protection Research Center

Introduction

The white mango scale (WMS) (*Aulacaspis tubercularis*) originated in Asia and was later distributed all over the world, is currently constraining the cultivation of mangos worldwide. CABI distribution map of pests show that *A. tubercularis* occurs in several countries of West Africa and several Sub-Saharan African countries [1]. In Ethiopia, the WMS was first reported in east Welega zone of the Oromia region in August, 2010 at a private farm (Green Focus Ethiopia Ltd). The pest can attack crops such as citrus, papaya, avocado, ginger, cinnamon, and pumpkin [2].

The study of the distribution and severity status of the WMS in east and west Welega zones and confirmed that maximum air distance covered by the WMS was 67km to the west (Gimbi district- Jogir kebele), on the way from Nekemte to Asossa, and 58km to the east (Gobu Sayo district-Sombo Kejo kebele), on the way from Nekemte it make reference from the WMS insect original infestation place at Guto Gida district (Loko Adiministrative kebele) [3]. There are no other recent studies on the distribution and severity status of the WMS in the south western part of Ethiopia. Knowledge of pest fluctuations in their ecology is very important along with weather factors that influence their population. However, there is no detail data concerning white mango scale population dynamics in Ethiopia. Therefore, these studies aimed at determining the distribution, severity status and the population dynamics of the WMS in south western Ethiopia.

Materials and Methods

Surveys were undertaken in south -western parts of Ethiopia during the 2016/2017 cropping season to study the distribution and severity status of the WMS (*Aulacaspis tubercularis*). The survey covered four major mango producing regions, viz: Sothern Nations, Nationalities, and Peoples (SNNP), Oromia, Gambella and

Benshul-Gumuz. This survey was carried out in ten (10) Zones, 43 districts and 97 sites. The survey started from east Welega zone, Guto-Gida district where the WMS was first reported in Ethiopia. Purposive sampling was used to select sampling sites depending on availability of mango farms/trees along road side at 5 to 10km intervals and leaf samples were collected. From each sampling site 5 mango plants were randomly selected, and sixteen leaves were collected from the mid canopy of the trees from four cardinal directions (North, South, West and East). In the case of the population dynamics studies, studies were carried out in western Oromia; east Welega (Didesa valley and Uke farm (Currently, Raj Agro-industry) and west Shoa (Bako-Tibe). Five mango trees similar in size and age were selected and marked at each site for this study. Samples were collected monthly during the period from October 2017 to September 2018. From each tree 20 leaves were collected from cardinal directions (North, South east and West) of the tree (four leaves per direction). Geographic data (Longitude, Latitude and Altitude) of each sampling site were recorded using a GPS. Weather factors such as maximum, minimum and mean of both temperature and relative humidity in each site were collected using Min/Max/Hygro-Thermometer (Delta TRAKR, Model #13301). Sampled leaves were transported to Ambo Agricultural Research Center (AARC). The leaves were examined under a stereomicroscope and life stages were counted. ArcGIS 10.3 was used for spatial data management and Mapping of White mango scale distribution. Relative frequencies of White mango scale occurrence at each site were calculated by the use of formula adopted from kataria and Kumar [5]. The value obtained was used to define severity index from which severity status at each site was determined Microsoft office excel was used for data organization. SAS 9.0 software package was used for population variation between surveyed districts. Pearson correlation was run to evaluate the relationship between WMS life stages population and weather conditions. The correlation coefficient range: absolute value of r: .00-.19 “very weak”, 0.20-.39 “weak”, 0 .40-.59 “moderate”, 0 .60-.79 “strong” and 0 .80-1.0 “very strong” were used to describe correlation coefficient strength [4]. Relative frequencies of WMS occurrence = Number of WMS recorded per mango site/Total number of WMS recorded from surveyed site.

Result and Discussion

Distribution and severity status

Table 1: Mean abundance (±SE) of White Mango Scale life stages recorded in south western part of Ethiopia during 2016/2017 cropping seasons.

District	Eggs (E)	Crawlers (C)	Females (F)	Males (M)
Gida Ayene	478.33±72.63^{a}	304.33±8.50^{c}	62.16± 8.12^{b}	385.13±100.52^{a}
Guto Gida	320.33±36.41^{dc}	243.64±36.75^{fe}	57.48±5.08^{b}	308.99± 93.39^{bac}
Abe-dongoro	437.38±64.03^{ba}	356.14±5.67^{b}	55.14±11.50^{ba}	337.03±44.37^{ba}
Gimbi	250.38± 45.25^{de}	291.42±19.44^{dc}	33.12±7.97^{def}	270.50± 45.47^{bc}
Arjo	61.21±14.04^{ih}	131.89±24.34^{h}	28.41±4.48^{gef}	143.62±60.57^{e}
Badale	284.52±55.5^{ef}	235.83±63.10^{fe}	35.82±9.95^{def}	266.17±49.69^{bc}
Debohena	186.91±28.98^{fe}	176.12±30.83^{g}	23.47±8.17^{ghf}	124.39±29.17^{e}
Bako tibe	174.35±35.35^{fe}	207.17± 20.59^{fg}	42.10±2.15^{dc}	248.89±73.39^{c}
Ilu gelan	43.51±19.49^{i}	25.58± 20.01^{k}	15.47±7.99^{h}	25.31±17.33^{f}
Homosha	481.97±16.79^{a}	448.98±10.17^{a}	67.47±6.26^{a}	353.41±9.88^{a}
Bambasi	476.69±15.41^{a}	436.74±7.27^{a}	66.16±1.54^{a}	370.09±26.30^{a}
Gambela twon	38.46±18.05^{i}	23.04±14.80^{k}	25.05±7.918^{ghf}	102.31±15.61^{ef}
Shako	356.23 ±14.0^{dc}	386.23±17.2^{bc}	46.12±14.32^{bc}	321.12±9.23^{cb}
Shebench	404.43±13.3^{ba}	458.53±12.^{a}	52.25±9.32^{ba}	345.73±5.33^{ba}
Yaki	340.93±16.1^{dc}	229.22±21.12^{fe}	29.98±11.32^{gef}	275.20±18.2^{bc}
Godere	328.39±23.12^{dc}	293.12±14.95^{dc}	43.23±15.64^{dc}	349.45±12.54^{ba}
CV (%)	25.03	13.77	20.54	25.07
LSD (0.05)	81.107	40.48	11.139	81.924
P Value	<.0001	<.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.

The present survey revealed that there were irregular patterns of white mango scale distribution and severity in south western party of Ethiopia. The pest was observed causing various degrees of severity in all surveyed areas (Table 1&2). Except some district of Jimma, Ilu-abba bora and west Welega, high to very high infestations were recorded in all surveyed areas with high numbers of white mango scale life stages (Table 1&2). During the survey WMS free mangos were recorded at Jimma zone (Sokoru,

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Saka, Shabe, Gumma, districts), Ilu-abba bora zone (Halu district) and west wellega (Mandi and Najo districts) (Table 3). There was significant difference in WMS life stages population densities recorded among the different districts. Population density of WMS life stages recorded at East Welega: High population density of White mango scale in these Zones resulted in high to very high severity status on mango trees in these particular zones (Table 3). Researchers reported that the white mango scale has the potential to devastate mango trees in Ethiopia [3,6].

Table 2: Severity status of White Mango Scale, *Aulacaspis tubercularis* in south western part of Ethiopia during 2016/2017 cropping seasons.

Region	Zone	District	Severity Index	Severity Status	Region	Zone	District	Severity Index	Severity Status
Oromia	East Welega	Gida Ayene	3	Very High Infestation	Oromia	Buno Badale	Dabohana	1	Mild Infestation
„	„	Guto Gida	2	High Infestation	„	Ilu abba bora	Matu twon	0	No Infestation
„	„	Gimbi	2	High Infestation	„	„	Badale	2	High Infestation
„	„	Wayo tuka	1	Mild Infestation	„	„	Yayu	0	No Infestation
„	„	Gechi	1	Mild Infestation	„		Halu	0	No Infestation
„	„	Gobu sayo	1	Mild Infestation	„	„	Sibusire	1	Mild Infestation
„	„	Gutu Gida	2	High Infestation	„	„	Hurumu	0	No Infestation
„	West Welega	Arjo	1	Mild Infestation	„	West shewa	Bako	2	High Infestation
„	„	Mandi	0	No Infestation	„	„	Ilu gelan	1	Mild Infestation
„	Horo-guduru	Abe-dongoro	3	Very High Infestation	Benshangul-gumuze	Assosa	Assosa	3	Very High Infestation
„	Jimma	Sokoru	0	No Infestation	„	„	Homosha	3	Very High Infestation
„	„	Kersa	0	No Infestation	„	„	Bambasi	3	Very High Infestation
„	„	Jimma twon	1	Mild Infestation	Gambella	Gambella	Gambelatwon	1	Mild Infestation
„	„	Saqa chokorsa	0	No Infestation	SNNP	?	Saja	0	No Infestation
„	„	Shabe	0	No Infestation	„	Kafa	Shabe sombo	0	No Infestation
„	„	Gomma	0	No Infestation	„	„	Gimbo	0	No Infestation
„	Buno badele	Didesa	3	Very High Infestation	„	Bench-Maji	Shako	3	Very High Infestation
„	„	Bure	1	Mild Infestation	„	„	Shebench	3	Very High Infestation
„	„	Bedele	0	No Infestation	„	Majang	Godere	3	Very High Infestation
	Buno Badale	Chora	0	No Infestation	„	Shaka	Yaki	3	Very High Infestation

Severely infested mango trees were observed with dry leaves and small sized fruits mostly infested by female white scales which usually drop early. Currently it has been reported that under heavy infestation premature fruit drop and smaller size is common [7]. The variations in population density recorded in the various administrative zones is probably caused by varietal difference, ecological variation, cultural practices of the individual farmers, elevation of the area, mango tree population scattered over surveyed areas and time of arrival of white mango scale to the area. According to Sunji (Personal communication) severity of white mango scale at Green focus (Raji agro-industry) varied across the different mango varieties in the farm. According to

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Sunji, the varieties Alphanso, Kent, Tommy Atkins and Dodo are susceptible to white mango scale. In contrast the varieties Apple and Keit are more tolerant to this pest.

This survey result indicates that spread of this insect is expanding to all western part of the country. The distribution of white mango scale probably facilitated by wind which may transports nymphal (crawlers) stage to neighboring plants. The report showed that white mango scale can move with the help of external forces like wind, birds and insect pests [8]. The WMS female is flightless insect but is mobile only at nymphal (crawler) stage. In addition to this long-distance dispersal of white mango scale life stages is also possible if infested planting materials (Leaves, twigs, fruits) and contaminated containers are transported within or outside infested areas (Figure 1).

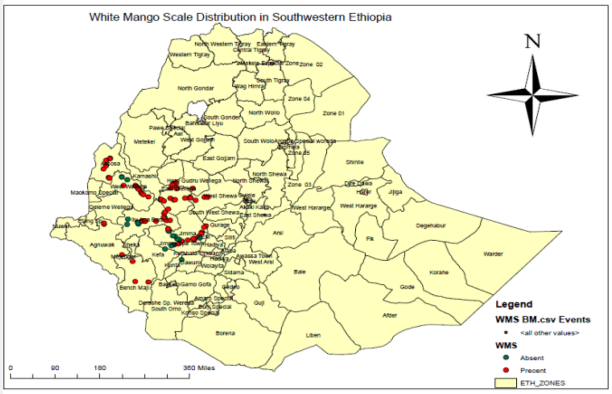

Figure 1: Map showing White Mango Scale surveyed areas in Southwestern Ethiopia during 2016/2017 cropping season.

Population dynamics

The WMS population data from October 2016 to September, 2017 indicates that, in all the three surveyed area, the population dynamics follow almost the same pattern. The number of WMS recorded was exponentially increased from October to March and reach the maximum peak in April in Didesa and Green focus sites (Figure 2A, 2B & 2C). After the month of April, the population dramatically declined through May and June, and then slightly increased in July. In case of Bako site, the population of WMS increased from October to April and reached the climax in May and declined through June to September. Similar report with this finding, three peaks per year in Egypt was recorded [9]. Similarly, the groups stated that the population peaks of the pest occurred during different periods of the year [10]. At Didesa valley the correlation analysis revealed that WMS life stage population showed that a very weak positive correlation with mean temperature (r=0.059), weak negative correlation with maximum temperature and weak positive correlation with relative humidity respectively recorded. At Green focus very weak positive correlation with mean temperature and moderate correlation with Maximum temperature and strong positive correlation with maximum relative humidity were recorded. In case of Bako site very weak positive correlation with mean relative humidity and moderate negative maximum temperature were recorded (Table 3). Data in table showed that in all sites Maximum temperature recorded with negative correlation with white mango scale population. WMS population peaks mainly depend on temperature and relative humidity of that locality [10]. Whether factors particularly the effect of temperature on insect biological behavior such as distribution and reproduction of insects, population size and sex ratio [11].

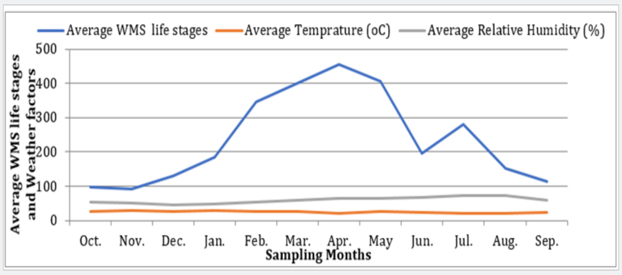

Figure 2A: Didesa valley WMS all alive stages Population dynamics along weather factors.

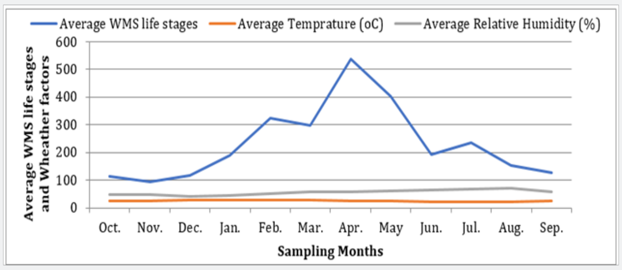

Figure 2B: Green Focus valley WMS average alive stages Population dynamics along weather factors.

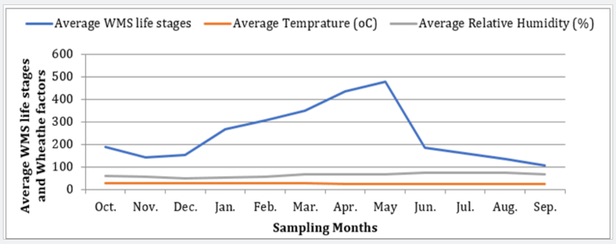

Figure 2C: Bako valley WMS average alive stages Population dynamics along weather factors.

Table 3: Correlation coefficient (r) of WMS life stages population on Mango with prevailing weather parameters during, 2016/17 cropping season at Didesa valley, Green Focus and Bako.

Weather Variables	Dedesa Valley		Green Focus		Bako	
	r	P	r	P	r	P
Maximum Temp.	-0.315	0.345	-0.495	0.121	-0.525	0.098
Minimam Temp.	0.464	0.1501	0.525	0.097	0.89	0.0002

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Mean Temp.	0.059	0.863	0.078	0.82	0.216	0.524
Maximum R.H	0.325	0.33	0.618	0.043	0.093	0.785
Minimum R.H	0.342	0.304	0.571	0.067	0.716	0.834
Mean R.H	0.335	0.315	0.602	0.05	0.085	0.805

*Correlation is significant at the 0.05 level, **Correlation is significant at the 0.01 level

Note: Absolute value of r: .00-.19 "very weak", 0.20-.39 "weak", 0 .40-.59 "moderate", 0 .60-.79 "strong" and 0 .80-1.0 "very strong" (Evans (1996).

Distribution within a tree

Table 4: Mean alive WMS (±) recorded in study areas during 2016/2017 cropping season.

Mean Alive WMS (±SE) Recorded in Study Areas									
Directions	**Didesa**			**Green Focus**			**Bako Tibe**		
	Crawler	**Female**	**Male Colonies**	**Crawler**	**Female**	**Male Colonies**	**Crawler**	**Female**	**Male Colonies**
North	43.4±2.9a	29.9±3.1b	32.9±9.5b	38.5±3.6d	36.0±5.8a	36.4±5.8c	48.5± 8.8b	24.1± 6.7b	38.7±9.4a
South	75.7±6.4b	38.2± 5.6a	41.8 ±1.2b	77.2±2.2a	40.8±10.0a	39.9±5.3bc	74.6±9.9a	36.3± 6.6a	43.4±10.2a
West	73.6±7.5b	31.7±7.3b	48.2±2.7a	65.9±3.1b	38.8± 5.9a	50.6±3.1a	46.5±9.3b	29.4± 6.8b	46.7±4.4a
East	72.1±6.2b	31.9±6.6b	50.5±4.1a	58.4±8.1c	30.3±7.9a	45.6±7.6ab	49.2±10.7b	23.4± 2.8b	38.8±8.9a
CV (%)	19.11	15.51	22.98	18.8	22.01	10.8	15.31	21.95	17.71
LSD (0.05)	8.31	7.04	13.73	7.28	11.07	6.42	11.54	8.56	10.23
F value	14.34	2.39	1.9	20.6	1.03	5.49	6.77	2.39	1.91
P value	<.0001	0.0882	0.1576	<.0001	0.4611	0.0051	0.0021	0.0888	0.1556

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

Didesa valley site: The distribution of the WMS significantly differences among the different cardinal directions. High numbers of WMS individuals per leaf were recorded in the South direction while lowest population was recorded in East direction and North direction. At Green focus except female all show significant difference among all direction. At this site we recorded high populations of individual per leaf in south and west direction (Table 2). At Bako site crawlers and females show significant difference in all direction. In current study we recorded high individuals per leaf in south and west direction respectively. The WMS life stage variation observed in present study probably caused by directional variation in weather factors such as wind force that may directly resist crawler establishment and indirectly increases evaporation that reduce moisture level, temperature difference, light intensity that may cause mortality during dry seasons. Labuschagne and his colleague's demonstration showed that south face is more prone than other face due weather factors differences (Table 4) [10].

Conclusion

The current survey showed that WMS distribution is expanding to all southwestern part of Ethiopia and considerably threatening mongo tree production and productivity. We observed very low population density (severity status) and white WMS free mango at Jimma zone (Sokoru, Saka, Shabe, Gumma, Gumayit district), Ilu-abba bora Zone (Halu district) and West welega (Mandi and Najo district). Population dynamics of WMS increased from October to March and reach the maximum peak in April in Didesa and Green focus sites. In case of Bako site, the population of WMS increased from October to April and reached the climax in May. In current study we recommend that during chemical spray emphasis need to be taken in south and west directions. From current study we recommend that regulatory measures, information dissemination need to be regularly updated though surveillance and monitoring activity to keep the population below economic threshold level particularly where infestation is low.

Coordination system among farmers, plant extension groups, healthy clinic, and professional expert should be facilitated and strengthen to minimize the risk. Movement of infested plants and plant products (fruit) from infested districts need to be prohibited through regular inspection. Management options such as conservation, unproductive large mango trees (source of inoculation) replacement, enhancing tolerant and manageable size mango variety, clustering mango potential zones, developing mango production package should be initiated by governmental intervention. IPM such as pruning, burn heavily infested branches, systemic insecticide, improving chemical application methods (soil drench, tree injection, modifying spraying mechanism for larger canopy of mango tree), enhancing native natural enemies population build up through rearing and re-inoculation, introduction of exotic natural enemies such as parasitoid need to be design as soon as possible for highly infested area such as Bench-Maji, East Wellega, West shoa zone and Assosa region to minimize the population size of white mango scale.

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Conflict of Interest

The authors have no any conflict of the interest.

References

1. CABI (2018) Data sheet. Aulacaspis tubercularis (mango scale). Invasive Species Compendium.
2. Mohammed Dawd BHG, Lemma Ayele, Konjit Feleke, Seyoum Hailemariam, Teshome Burka WMS (2012) A new insect pest of mango in western Ethiopia. Proceedings of the 3rd biennial conference of Ethiopian Horticultural science Society.
3. Fita T (2014) White mango scale, Aulacaspis tubercularis, distribution and severity status in East and West Wollega Zones, western Ethiopia. Science, Technology and Arts Research Journal 3(3): 1-10.
4. Wuensch KL (1996) Straightforward Statistic for the Behavioral Sciences. Journal of the American Statistical Association 91(436): 1750-1751.
5. Kataria R, Kumar D (2012) Occurrence and Infestation level of sucking pests: Aphids on various host plants in Agricultural fields of Vadodara, Gujarat (India). IJSRP 2(7): 1-6.
6. Ofgaa D, Emana D (2015) Infestation of Aulacaspis tubercularis (Homoptera: Diaspididae) on mango fruits at different stages of fruit development, in western Ethiopia. Journal of Biology, Agriculture and Healthcare 5(18): 34-38.
7. Abo-Shanab A (2012) Suppression white mango scale, Aulacaspis tubercularis Newstead (Hemiptera: Diaspididae) on mango trees in El-Beheira Governorate, Egypt. Egypt Acad J Biolog Sci 5(3): 43-50.
8. Greathead DJ (1997) 1.3. 3 Crawler behaviour and dispersal. World crop pests 7(Part A): 339-342.
9. El-Metwally M, Moussa S, Ghanim N (2011) 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 4(1): 123-130.
10. Labuschagne T, Van Hamburg H, Froneman I (1995) Population dynamics of the mango scale, *Aulacaspis tubercularis* (Newstead) (Coccoidea: Diaspididae), in South Africa. Israel Journal of Entomology 29: 207-217.
11. Grossen C, Neuenschwander S, Perrin N (2011) Temperature-dependent turnovers in sex-determination mechanisms: a quantitative model. Evolution 65(1): 64-78.

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