



Factors Influencing White Mango Scale (*Aulacaspis tubercularis*) Infestation Status at Assosa and Bambasi Districts, in Benishangul Gumuz Region, Western Ethiopia

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ABSTRACT

Background: This research was conducted to assess factors affecting white mango scale infestation status from August 2018 to April 2019.

Methods: Survey data was collected from randomly selected of 7 *kebele* administration and 35 mango orchards as 5 per *kebele* administrations within 5-10 km interval. Stratified sampling method was used for selecting 3,150 sample leaves from 35 mango trees for counting the clusters of white mango scale.

Result: The survey result showed that temperature in contrary with rain fall and relative humidity was significantly and positively related with the infestation status. Mango orchards characteristics of old age, tall size, crowded canopy, other plant availability in the orchards, mango trees planted without appropriate spacing and weed infestation provide favourable condition for the aggravation of infestation status. Therefore it is recommended to develop regular inspection, monitoring and appropriate agronomic practices for providing sustainable management approach.

Key words: Infestation status, Mango orchard characteristics, Metrological data, White mango scale.

INTRODUCTION

Mangoes (*Mangifera indica* Linnaeus) are tropical and subtropical fruits widely grown across the world (Louw *et al.* 2008; Evans *et al.* 2017). There are various mango genotypes with various germination and production capacities (Reshma and Simi, 2021). Different mango genotype grown in Ethiopia mainly in the Rift Valley, western and south western Ethiopia with consideration given to its socio-cultural legacy and current scale of production (Anshuman *et al.* 2015; Tewodros *et al.* 2019).

Mangoes (*Mangifera indica* Linnaeus) are affected by a variety of pests, most notably stink weevil, mealy bugs, fruit flies, scales, thrips and mites and various fungal diseases (Hussen and Yimer, 2013; Kannan and Dhivya, 2021; Bincader *et al.* 2021). Of these, white mango scale (*Aulacaspis tubercularis* Newstead) has been reported to cause severe damage to mangoes around the world (Abo-Shanab, 2012). The white mango scale yellows the leaves of the mango plant, makes pink blemishes on mature and ripe mango fruits and dieback of the plant (El-Metwally *et al.*, 2011; Abo-Shanab, 2012).

The pink blemishes on the mango fruit is causing an economic downturn by preventing it from being exported (USDA, 2007). Various studies have shown that white mango scale has spread to various mango growing areas in Ethiopia since its inception in 2010 at Green Focus Ethiopia Ltd. Mango orchard farm (Fita, 2014; Ayalew *et al.* 2015).

In western Ethiopia, the white mango scale had a significant impact on mango production, attracting the concern of various government institutions, civil societies and communities. This is due to the fact that the mango

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plant is providing significant social and economic benefits for animal shade, public gatherings, sources of income and food. Thus, the problem of this pest is not only economic but also social, environmental and other consequences (Djirata and Getu, 2015).

Therefore, the main objective of this study was to identify some factors influencing the spread of white mango scale insect pests in the farm of mango orchards and to provide recommendations for mango producers and to contribute to future research on white mango scale management.

MATERIALS AND METHODS

Description of survey area

The study was conducted in Assosa and Bambasi districts of Asosa Administrative Zone, Benishangul Gumuz Regional

State. Benishangul-Gumuz is located in western Ethiopia, 687 kilometers from Addis Ababa (The capital city). The region is located at 9°30'-11°30' latitude and 34°20'-36°30' longitude, with an area coverage of 50,380 square kilometers, altitude of 580-2731 meters above sea level, annual ambient temperature of 17-29°C and annual average rainfall of 860-1600 mm (NMA, 2015). The region produces maize, sorghum, soybeans, mangoes, bananas, lemons, oranges and others. However, the mango among the fruit crops is widely grown, especially in the Assosa administrative zone (BGRS BoA, 2017; CSA, 2017). Bambasi is one of the districts surveyed in Assosa Administrative Zone, 45 km from Asosa, the regional capital. The geographical location of the district is lies between 9°45' latitude and 34°45' longitudes, the area coverage is 2100 square kilometers, the altitude is 1100-1450 meter above sea level, the average annual rainfall is 1350-1450 mm and the annual ambient temperature varies from 21-35°C (NMA, 2015). The district mainly produces maize, sorghum, soybeans, mangoes, bananas, lemons, oranges and others (BGRS BoA, 2017). The other study area was Assosa district, with a geographical location lies between 10°042-10.0670 latitude and 34°312 - 34.5170 longitudes, area coverage 2317 square kilometers, altitude between 1401-1544 meter above sea level, average annual rainfall 900-1200 mm and annual ambient temperature range from 21 to 31°C (NMA, 2015). The main crops grown include sorghum, maize, soybeans, ground nut, sweet potatoes, bananas, mangoes and more (BGRS BoA, 2017). Fig 1 showed the study location map of both Bambasi and Assosa districts.

White mango scale assessment

The white mango scale infestation status survey was conducted for nine months from August 2018 to April 2019.

Mango orchards for the study were selected using a multi-stage sampling method. Assosa and Bambasi districts were selected on purposive sampling method basis. It is home to the largest mango plantation in the region and the infestation of white mango scale. Next, based on the number of mango plantations in both districts, by proportional sampling method from Assosa district, Amba-14, Amba-5, Amba-8 and Megele-32 and Bambasi district, Villages-47, Village-48 and Sonka in general seven *kebele* administrations (peasant administrations) were selected (Mulat and Tadele, 2001). Finally, after a distance of 5-10 km, a mango orchard with at least ten mango trees was selected, with five mango orchards selected in each *kebele*. In this way, the mango tree is marked by selecting an average representative of the mango orchard. Although the pest attacks parts of the mango tree, such as the leaves, branches and twigs, a leaf sample was taken to make it easier to quantify the scale cluster, according to most studies (Merkuz *et al.* 2021; Fita, 2014; Djirata *et al.* 2016). Using the stratified sampling method, the marked mango tree canopy was divided into three parts: three leaves from the top canopy, four leaves from the middle canopy and three leaves from the bottom canopy a total of ten leaves were taken for nine consecutive months. Accordingly, 90 leaves of one tree and 3,150 leaves of 35 trees were sampled. The sample was then placed in a polyethylene bags and immediately taken to the Assosa Plant Health Clinic for a white mango scale cluster count with a hand lenses as illustrated in Fig 2 (Fita, 2014; Djirata *et al.* 2018).

The infestation and the degree of damage was recorded by using a scoring method from 0 to 5 scale by relating percentage of panicle destroyed / damaged and cluster formation per leaf with each other as illustrated in Table 1 (Williams *et al.*, 2009; Fita, 2014).

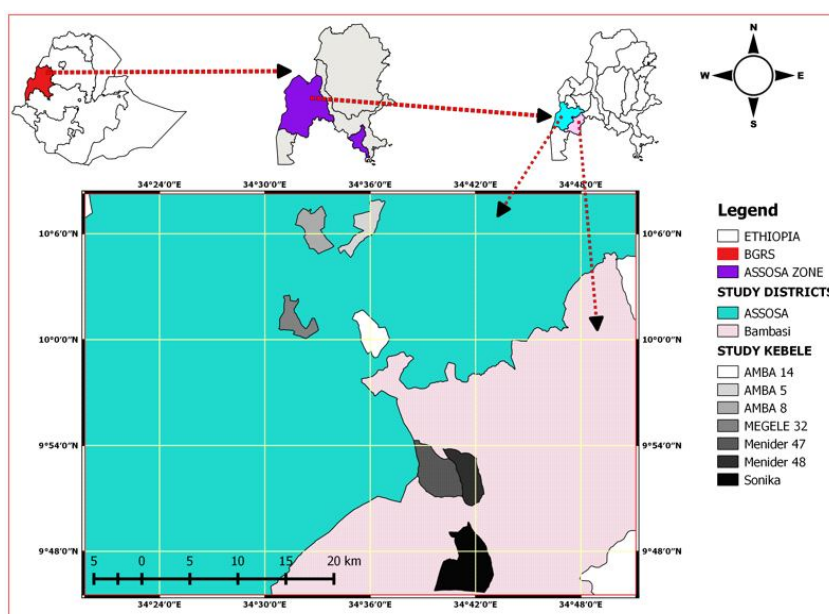


Fig 1: Location map of the study site (Merkuz *et al.* 2021).

Collected survey data

Qualitative and quantitative data for the study were taken. Mango orchard characteristics: age, height, canopy size, planting pattern/spacing, Intercropping condition, weed infestation status, average white mango scale cluster number per leaf, severity of infestation: free, minimal, medium, severe and very severe, as well as meteorological data average rainfall, average relative humidity and average Temperature data were collected.

Statistical analysis of the survey data

The association of Meteorological data such as mean monthly rain fall, temperature and relative humidity with white mango scale cluster abundance per leaf was analysed using Pearson correlation coefficient with corresponding p -value (PROC CORR) (Gomez and Gomez, 1984; SAS, 2009). The effect of explanatory variable of mango orchard characteristic factors which determined the severity status of the responsive variable of white mango scale categorical data were analysed by odds ratio to measure the strength of the association and Chi-Square (χ^2) test for the significance at 5% error level using cumulative logit model of PROC LOGISTIC PROCEDURE (Gomez and Gomez, 1984; SAS, 2009). Count data of white mango scale was subjected to square root transformation [$\sqrt{(x + 5)}$] before analysis to stabilize the variance. Homogeneity of variance of the sample was tested using Levene's test before and after data transformation ($p > .05$) (Gomez and Gomez, 1984; SAS, 2009). The data were reported in the text using the back transformed values. Microsoft Excel was used to summarize survey data.

RESULTS AND DISCUSSION

Observation in the study districts of mango orchards indicated that different factors were influencing the white mango scale infestation status. White mango scale insect infestation status was significantly correlated with meteorological data such as rain fall, temperature and relative humidity. In Assosa orchards mean cluster abundance was significantly and more degree of negative correlation to mean monthly relative humidity ($r_{178} = -0.532$, $p < .01$) than to mean monthly rain fall ($r_{178} = -0.277$, $p < .01$). These findings indicated that mean cluster abundance somehow more varied by mean monthly relative humidity than mean monthly rain fall. In orchards of Bambasi also mean cluster abundance was significantly and negatively related to mean monthly rainfall ($r_{133} = -0.380$, $p < .01$). In both Assosa and Bambasi orchards mean cluster was significantly and more strongly positively related to mean monthly temperature ($r_{178} = 0.898$, $p < .01$) and ($r_{133} = 0.838$, $p < .01$) respectively (Table 2).

White mango scale insect pest infestation status was showed a progressive change through out the study periods with the change of mean monthly rain fall, mean monthly temperature and mean monthly relative humidity. Fig 3 illustrates the impact of mean monthly rain fall and mean monthly temperature on mean cluster abundance per leaf at Bambasi district. Maximum cluster abundance 14.1 per leaf was recorded at the maximum temperature records of the study period during April, 2019 at maximum temperature 35.64°C and minimum temperature 20.84°C and mean monthly rain fall 39.2 mm. Mean cluster abundance per leaf was observed decreasing while there was a continued and high rain fall from August a mean monthly rain fall record of

Table 1: Infestation and degree of damage of mango trees using zero to five scales.

Infestation status /degree of damage	Panicle destroyed/damaged	Clusters formation per leaf	
Free	<5%	<1	Free or Zero for less than one cluster formation
Minimal	5 to 24%	>1.0-2.0	Minimal for greater than one and less than two clusters formation per leaf
Moderate	25 to 50%	>2.0-4.0	Moderate for greater than two and less than four clusters formation per leaf
Severe	51 to 70%	>4.0-5.0	Severe for greater than four and less than five clusters formation per leaf
Very severe	71 to 100%	>5	Very severe for greater than five clusters formation



Fig 2: Severity status of white mango scale.

Table 2: Correlations of white mango scale cluster abundance per leaf with mean monthly rain fall, temperature and relative humidity in Assosa and Bambasi orchards.

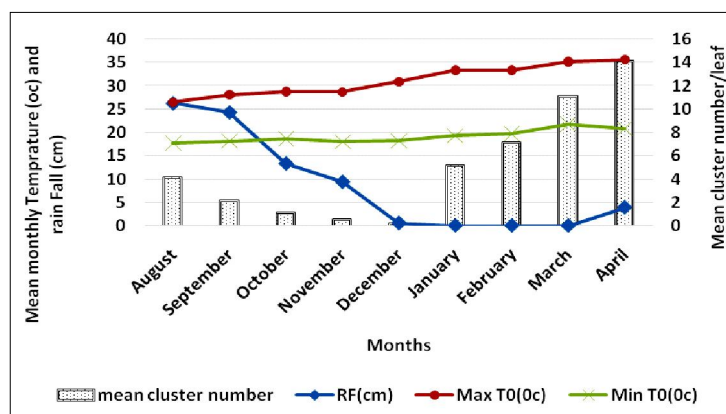
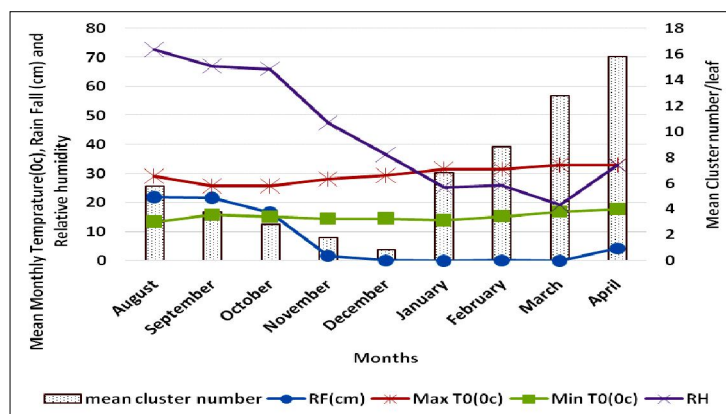
		Rain Fall	Temperature	Humidity
Assosa	r_{178}	-0.277	0.898	-0.532
	P	0.0002	<.0001	<0.0001
Bambasi	r_{133}	-0.380	0.838	-
	P	<.0001	<.0001	-

263 mm to December a lower mean monthly rain fall record of 5.2 mm during which a minimum 0.19 mean cluster abundance per leaf was recorded.

Similarly in Assosa district as shown in Fig 4 the abundance of mean cluster per leaf was varied with the change of mean monthly rain fall, mean monthly temperature and mean monthly relative humidity through out the study periods. Mean cluster abundance per leaf was decreased from August to December coincides with lowering of mean monthly relative humidity and mean monthly rain fall. Building up of cluster abundance coincides with a startup of mean monthly relative humidity and mean monthly rain fall increment starting from March. Maximum cluster abundance 15.8 per leaf was recorded during April, 2019 at maximum temperature 32.9°C, minimum temperature 17.8°C, optimum

mean monthly rain fall 42 mm and mean monthly relative humidity 32%. Cluster abundance per leaf was observed decreasing while there was a continued and high rain fall starting from August a mean monthly rain fall record of 218.9 mm to December a minimum mean monthly rain fall record 1.5 mm during which minimum mean cluster abundance 0.86 was recorded.

In general these studies indicated that white mango scale insect pest abundance and infestation status was significantly correlated with moterological data such as rain fall, temperature and relative humidity. White mango scale abundance and infestation status were significantly and inversely correlated with rain fall and relative humidity and directly correlated with temperature. The infestation status was decreased with the increased rain fall and relative humidity and increased with the increased temperature. Maximum cluster abundance and infestation status were recorded during maximum temperature records' while the study month of 'April'. The build up of white mango scale abundance and infestation status required optimum rain fall and relative humidity. These study result also supported by different literature such as: temperature variation affect the white mango scale populations, peak populations were recorded in the months with maximum monthly temperatures of 35 and 31°C at Arjo and Bako of western Ethiopia,

**Fig 3:** Progressive change of mean cluster/leaf with mean monthly Rain fall and Temperature at Bambasi.**Fig 4:** Progressive change of mean cluster/leaf with Rain fall, Temperature and Relative humidity at Assosa.

respectively. Extremely low population level below 10 mm average monthly rain fall (highly affected by drought) and in contrary heavy and continued rain fall decreases the population (Djirata *et al.*, 2018). Maturation and ripening of mango fruit begin during the first months of rainy season that is, in March to April and continues for few months, vis-a-vis significant infestation of mango fruits by white mango scale, in Western Ethiopia (Djirata and Getu, 2015). However; this result contradicted with the earlier finding that white mango scale had a low tolerance to high temperature and as a result its population declined in temperatures above 30°C (Labuschagne *et al.* 1995).

The severity of mango white scale infestation was also related to the characteristics of the mango orchards as indicated in Table 3. Mango white scale severity of infestation was related to the age, height, canopy size, planting pattern, intercropping and weed infestation status of the mango orchards.

White mango scale insect pest infestation status significantly varied for different age category of mango trees ($\chi^2_{.95} (2) = 7.48, p < .05$). Mango orchards in age less than 10 years old age group were at 51% lower risk of minimal to

moderate severity status compared to greater than 20 years old age mango trees group (OR: 0.49; 95% CI: 0.29-0.817). Since the old age mango trees leave without any agronomic management which become suitable for the reproduction of the pest and used for source of infestation. Other study result indicated that according to the oldness of the trees age most farmers did not give attention to mango trees plantation (Hussen and Yimer, 2013).

White mango scale insect pest infestation status significantly varied for different height category of mango trees [$\chi^2_{.95} (3) = 11.8, p < .05$]. Mango orchards in short height group were at 60% lower risk of minimal to moderate severity status compared to very long height mango trees group (OR: 0.40; 95% CI: 0.22-0.739). Very long height mango trees were observed more likely at risk of minimal to medium severity status. Unmanageable sized mango trees were observed difficult for management application and since significant contribution for white mango scale infestation. Studies indicated that tall trees present a harvesting problem and create difficulties during spraying and pruning (Griesbach, 2003).

Table 3: Effect of mango orchard characteristics to white mango scale severity status.

Effect		Odds ratio estimates			Pr >ChiSq
		Point estimate	95% Wald confidence limits		
Moderate vs Free	Intercept				<.0001
Minimal vs Free	Intercept				<.0001
Age					0.0237
	10_20 Years vs>20 Years	0.7	0.433	1.137	0.9792
	<10 Years>20 Years	0.49	0.29	0.817	0.0212
Moderate vs Free	Intercept				<.0001
Minimal vs Free	Intercept				<.0001
Height					0.0081
	Long vs Very Long	0.73	0.428	1.238	0.2899
	Medium vs Very Long	0.45	0.254	0.809	0.1388
Short vs Very Long		0.4	0.22	0.739	0.0476
Moderate vs Free	Intercept				<.0001
Minimal vs Free	Intercept				<.0001
Canopy					0.0167
	Crowded vs uncrowded	2.08	1.248	3.465	0.0074
	Less crowded vs uncrowded	1.37	0.803	2.334	0.8174
Moderate vs Free	Intercept				<.0001
Minimal vs Free	Intercept				<.0001
Intercropping					0.0066
	No vs Yes	0.561	0.37	0.851	0.002
Moderate vs Free	Intercept				<.0001
Minimal vs Free	Intercept				<.0001
Planting pattern					0.0177
	Not recommended vs Recommended	1.75	1.102	2.774	0.0177
Moderate vs Free	Intercept				<.0001
Minimal vs Free	Intercept				<.0001
Weed					0.0167
	High vs Medium	0.66	0.405	1.07	0.8174
	Low vs Medium	0.48	0.289	0.802	0.0266

White mango scale insect pest infestation status significantly varied for different canopy volume category of mango trees ($\chi^2_{.95} (3) = 8.18, p < .05$). Mango orchards in crowded canopy group were at 2.08 times more at risk of minimal to moderate severity status compared to uncrowded canopy mango trees group (OR: 2.08; 95% CI: 1.248-3.465). The uncrowded canopy volume in which sun light easily penetrate to inner canopy and also free air movement made lower infestation of white mango scale. Studies indicated that well managed orchard trees require regular annual pruning to maintain an open canopy of manageable size which allows air and sunlight to penetrate, which reduces pests and diseases (Bally, 2006). Also other studies suggested that regular canopy management necessary for mango yield improvement (Sharma and Singh, 2006).

White mango scale insect pest infestation status significantly varied for different planting pattern or spacing of mango orchards ($\chi^2_{.95} (1) = 5.62, p < .01$). Mango orchards in not-recommended planting pattern group were at 75% more likely at risk of minimal to moderate severity status compared to recommended planting pattern mango trees group (OR: 1.75; 95% CI: 1.102-2.774). It was observed that mango trees planted with recommended planting space which is used regularly 10 m × 10 m as general guide of the study districts were less likely at risk of minimal to moderate severity status. Studies reported that since mango trees grow in to large specimen need appropriate spacing; high-density planting show a progressive decline in crop yield after 14-15 years, due to overcrowding of canopies, which results in the production of fewer fruits which are apt to be poorly colored and infected with pests (Sharma and Singh, 2006; Hussien and Yimer, 2013; Khan *et al.* 2015). Some fact sheets suggested that adequate plant spacing which allows greater air movement and increases pesticide coverage and also reduces ideal environments for scale insects to develop and increases the ease of detection (Andrew, 2019).

White mango scale insect pest infestation status significantly varied by intercropping condition of mango orchards ($\chi^2_{.95} (1) = 7.37, p < .01$). Mango orchards in not-intercropped group were at 44% lower risk of minimal to moderate severity status compared to intercropped mango trees group (OR: 0.56; 95% CI: 0.37-0.851). Also white mango scale insect pest infestation status significantly varied for different weed infestation status category of mango orchards ($\chi^2_{.95} (2) = 8.18, p < .01$). Mango orchards in low weed infested group were at 52% lower risk of minimal to moderate severity status compared to medium weed mango trees group (OR: 0.48; 95% CI: 0.289-0.802). Mango trees intercropped with other plants and infested by weed were more likely attacked by white mango scale comparatively high infestation status. The intercropped plants and weed might be used as harbor and contributing for overlapping generation of the white mango scale insect pest. Studies suggested that for scale management removing crop debris and disinfest the growing area and free of weeds since scale

may survive for weeks on crop debris and in egg masses that have fallen off plants (Andrew, 2019).

CONCLUSION

The infestation of white mango scale insect pest was observed throughout the study periods. However the infestation status varied with temperature, rain fall and relative humidity and also varied with mango orchard characteristics of age, height, canopy volume, intercropping, planting pattern and weed infestation status. Temperature influence the infestation positively and a maximum record during maximum temperature of the study month during April. High and continued rain fall and relative humidity influence infestation negatively. However optimum rain fall and relative humidity starting from March to April enhance infestation. Mango orchard characteristics of old age, tall size, crowded canopy, other plant availability in the orchards, mango trees planted without appropriate spacing and weed infestation provide favourable condition for the aggravation of infestation status. Therefore it is recommended to regular inspection and monitoring of white mango scale insect pest and develops appropriate agronomic practice of mango orchards like pruning, grafting and appropriate spacing, avoid intercropping with plants used as harbor, weeding and other management practice to come with sustainable strategy for management of white mango scale and increase productivity of mango fruits.

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Conflict of interest

The authors declare no conflict of interest.

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