ADDIS ABABA UNIVERSITY, SCHOOL OF GRADUATE STUDIES

The Current status of white mango scales at Uke, the area of first report in Ethiopia.

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A thesis submitted to Addis Ababa University, Department of Zoological Sciences

In Partial Fulfillment of the Requirements for the Degree of M.Sc in Biology

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Addis Ababa, Ethiopia

August 2018

Acknowledgement

I would like to extend my heartfelt gratitude thanks to my Adviser, Professor Emana Getu who inspired me to work on this topic, for his continuous guidance and support, friendly approach and invaluable comments. I am also thankful to Ato Asfaw Tegeng the School Director of Uke Preparatory for his material support.

I would like to extend my heartfelt gratitude to Uke FTC Leader and Uke kebele manager Ato Talila Jaleta and Ato Ayele Terefe for their support during data collection.

I would like to thank Kafyalew Kenea and other staff members for their moral support. Especial thanks to Addis Ababa University for its financial support to accomplish this study.

I would like to extend my heartfelt thanks to the Wollega University Librarian staffs for their support.

Especial thanks goes to my wife, Chaltu Asefa, for her all round support during my research work.

Acronyms /Abbreviations

Ha	Hectare
Km	Kilometer
Mm	Millimeter
A.s.l	Above sea level
M	Meter
UAAIE	Upper Awash Agro Industry Enterprise
C^0	Degree celicus
FTC	Farmer Training Center
CSA	Central Statistics Authority
WMS	White Mango Scale
GIS	Geographical Information System
LTD	Limited
PLC	Private Limited Company

Abstract

Tropical and sub-tropical fruits make a significant direct contribution to the subsistence of small–scale farmers by providing locally generate nutritious food that is often available when other agricultural crops have not yet been harvested.

Mango (*Mangifera indica L*) is the third most important fruit crop in the tropics and sub-tropics following Citrus and Banana. It is consumed as a fresh fruit and different form of preparations for its high contents of sugars, vitamins, minerals, protein and known to play a vital role in export and import business. Mango suffers from several diseases and insect pests and its trunk, branches, leaves, petiole, flower and fruit are attacked at all stages of its development. In Uke mango is also produced for Domestic consumption and export market and its production is constrained by infestation of white mango scale (*Aulacaspis tubercularis Newstead)* which was identified in 2010 from Guto Gida district from mango orchard located at Loko village in East Wollega Administrative Zone of Western Ethiopia. It spread and has become a threat to mango production in the kebele and affected economic benefits of mango farmers. The objective of this study was to investigate the distribution, severity status and its impact on farmers' income across district and kebeles were there are mango plantations. From the current study, white mango scale was the crucial mango production limiting factor in East Wollega because of its high rate of dispersal in all mango plantations in the vicinity. The data was collected randomly from January 15/5/2010 to June 15/10/2010 from the orchard of Green focus and Questionnaire was distributed for purposively sampled population. The result of study showed that high population peaks of WMS was recorded and distributed from its original point with high and very high infestations across district and kebeles in km. Most mango grower farmers used cultural methods to control the pests. The current study concluded that WMS was spreading very fast across district and kebeles from it first locus, and it is recommended that the infestation on mango can be reduced by the use of farmers indigenous knowledge of pest management practice.

Key words: *Mangifera indica L*, White mango scale, Distribution, Severity status, Management Practice.

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Chapter One

1.1 Introduction

Tropical and Sub-tropical fruits make a significant direct contribution to the subsistence of small–scale farmers by providing nutritious food that is often available when other agricultural crops have not yet been harvested.

Mango (*Mangifera indica L*) is the third most important fruit crop in the tropics and sub-tropics following Citrus and Banana. It is consumed as a fresh fruit and different form of preparations for its high contents of sugars, vitamins, minerals and protein among others (Ofgaa, 2017). It also used as animal feeds and known to play a vital role in export and import business and hence, generates foreign currency. Amee (2013) stated that mango is the king among tropical and sub-tropical fruits and is greatly needed for its succulence, exotic flavor and delicious taste in most countries in the world.

Marketing fresh and processed fruit products generates income which can act as an economic buffer and seasonal safety net for poor farm households. Diversification into fruit production can generate employment and enable small-scale farmers to begin on a range of production, processing and marketing activities to complement existing income generating activities (Takele, 2014).Mango is a member of the family *Anacardiaceae* within the genus *Mangifera* which consists of over 25 species ,of which *Mangifera indica L* is the only grown commercially in large scale and various literatures underline that mango was originated in tropical Asia and has been distributed, naturalized and adapted to tropical and sub-tropical regions throughout the world(Emana *et al.*,2015). Mango is fruit cultivated in more than 85 countries in the world and the widely and globally traded tropical and sub-tropical fruit trees in the world (Takele and Temesgen, 2014). The total amount of mango production in the world was around 35 million tons per year and its production is only preceded by citrus and banana (FAO, 2009). The mango crop is among the crops cultivated in Ethiopia and in southwest Ethiopia, while in south-west Ethiopia, mango is the first fruit crop grown (Tesfaye *et al.,* 2014 cited from Edossa *et al.,* 2006). Mango is one of the most important income-generating fruit in the rural communities of Western Oromia and contributes to the county's economy through feeding the local communities ,ecological balance and foreign exchange earnings(Duressa,2018).The area of mango production in the different regions is about 3789.47 ha in Oromia, 3375.89 ha in SNNPR, 652.56 ha in Benishangul Gumz, 246.85 ha in

Amahara, 180.41 ha in Gambella, 44.5 ha in Dire Dawa, 33.52 ha in Somali, 118.20 in Tigray and 367.24 ha in Harari. The total area allotted for mango is about 8808.64 ha and the country annual production of mango from all mango growing regions is about 697,507 quintals (Tesfaye *et al.*, 2014 cited from CSA, 2012/2013). In the same way in East Wollega, particularly, Uke kebele of Guto Gida district is commonly known in mango production. Global warming has modified environmental conditions of different regions because of an increase in greenhouse gas emissions, particularly, temperature, rainfall and relative humidity (Amanda *et al.*,2005).These phenomenon has generated changes in population development and ecology of diverse plant and animal species, thus favoring displacement of diverse pest and diseases to other locations, an important problem, in terms of pathogens such as fungi, bacteria and viruses as well as the vectors involved (Amanda *et al.*,2005). This situation is supported by the presence of natural enemies of the pests in new area of distribution resulting in increase in abundance of acquition of new host and pathogen transmission (Tesfaye *et al.*, 2014).

The introduction of the insect pests, plant disease and other pests is associated with the commodity brought mainly during accelerated agricultural development in different countries, when plants and plant products were brought or sent with no concern for a disease and insect pests were transported along them. Due to imports of mangoes with tropical and sub-tropical countries, the possibility for introduction of the pests along with the commodity remains treats (www.bione.org.). In similar way, in Ethiopia mango is cultivated and is preceded in importance only by citrus and banana (Tesfaye *et al.*, 2014). Mangos in Ethiopia are developed from seedlings and are inferior in productivity and quality. To alleviate these problems improved varieties of mango were introduced from Israel in 1983 and are being commercially produced and distributed to different parts of Ethiopia by Upper Awash Agro Industry Enterprise (UAAIE).In 2001/2002 a private farm called Green Focus ltd. introduced a new mango cultivar called Alphanson from India and planted on its farm at Loko Administrative kebele in Guto Gida district of East Wollega Zone.(Temesgen,2014).Many farmers grow mango for the source of food ,income and shading purpose and in Benishangul-Gumuz Regional state in particular, and other parts of western Ethiopia, in general, mango tree is used as a shade for livestock and conference hall for local people during hot and weather conditions (Ofgaa,2017).

Mango is considered as an important element in some certain sociological aspects in some parts of Ethiopia. From the observation point of view the newly introduced mango varieties to this locality differ in its annual productions when compared with that of the local mango varieties.

Mango suffers from several diseases at all stages of its development i.e. right from its nursery stage to grown-up tree stage and infected fruits at pre-harvest stages become less marketable and export (Temesgen, 2014 cited from Brown, 1992). Mango is attacked by a variety of insect pests such as stone weevil, (*sternochetus sp*.), mealy bugs, fruit flies, scales, and mites and various diseases of which fungal diseases are the most common (Emana *et al.,* 2015).All parts of the plants: trunk, branches, leaves, petiole, flower and fruit are attacked by insect pests. Among the insect pests infecting mango, white mango scales, *Aulacaspis tubercularis Newstead* is one of the agriculturally important devastating insect pests belong to order Hemiptera and known in having a piercing and sucking mouthpart and it became a serious pest on mango in all mango orchards in many countries (Emana *et al.,* 2015, Tsegaye *et al.,* 2017).

These insect pests affect the production and expansion of mango in Ethiopia. Post-harvest physiology and storage of tropical and sub-tropical fruits are very important (Mitra *et al.,* 2005). The world fruit trade is expanding, but mango scales are restricted by improper handling and inadequate transport facilities. Disease problems, sensitivity to low storage temperatures and the general perishable nature of the fruit limit transport distances of fresh fruits from the site of harvest. Mango fruits are usually harvest unripe (Mitra, *et al.,* 2005). Mitra *et al., (*2005) stated that mango tree is subjected to chilling injury when stored below $10c^0$ and the system which may not develop until the fruit is returned to high temperature. The production of mango is constrained by insect pest and the quality and productivity become decreased. In East Wollega Zone until 2010 there was no report indicating that insect pest attack mango plant in that part of the country. In December 2010, white mango scale, was reported from the low land areas in an orchard of Indian company, Green Focus ltd, in Western Ethiopia (Ofgaa *et al.,* 2017). In the early emergence of the pest the growers considered the pest as diseases, as the symptoms were drying of leaves and die-back of twigs. Expertise team report later confirmed that the pest was white mango scale which is a new pest for the locality. Plan International Ethiopia-Oromia Programme Area has initiated mango value chain project for beneficiaries of mango growers' farmers in Guto Gida and Diga districts of East Wollega Zone of Oromia Regional State to enhance mango productivity ,production and quality as

well as to create access to potential market for fresh and processed mango products, empower farmers to involve on value chain process and implementing community managed saving and loan association (Tesfaye *et al.*,2014).The overall goal is to bring a sustainable utilization of mango fruits for improved economic development through improved families in food security and to promote improved livelihoods. However, the project's assumptions made were failed due to the infestation of the fruit, either by insect pests or diseases. This risk was escaped at this stage due to lack of adequate information on the pest at that time because the scale was new to our country there had been little was known about it.

The insect capability to reproduce itself and spread over a wider geographical area within a short period of time was beyond the one could imagine (Tesfaye, *et al*., 22014). The overall generation of white mango scale is from 35-40 in females and 23-28 days in males (Ofgaa, 2017). Apart from the above institutional efforts at initial level, there has not been a strong institutional support has yet provided to the farmers to manage the pest. This situation has provided a fertile ground for the insect to spread and resulted in a full-scale infestation that disrupted the production and marketing process. For this reason, the pest become now more serious and growing concern of all actors working with mango grower farmers in the area.

This study was conducted with the following objectives to investigate the current status of the pest at Uke kebele of Guto Gida district of East Wollega Zone of Oromia Regional state and to study the impact of pest on the income of the local farmers of the kebele.

1.2 Statement of the problem and justification of the study

Tropical and Sub-tropical fruits make a significant direct contribution to the subsistence of small–scale farmers by providing nutritious food that is often available when other agricultural crops have not yet been harvested (Takele, 2014). Amee (2013) stated that mango is the king among tropical and sub-tropical fruits and is greatly valued for its succulence, exotic flavor and delicious taste in most countries in the world. Mango is the third most important fruit crop in the tropics and subtropics following Citrus and Banana. It is consumed as a fresh fruit and different form of preparations for its high contents of sugars, vitamins minerals and protein, among others and known to play a vital role in export and import business and hence generates foreign currency (Ofgaa,

2017). Marketing fresh and processed fruit products generates income which can act as an economic buffer and seasonal safety net for poor farm households'.

Mango in Ethiopia is developed from seedlings and is inferior in productivity and quality.
To alleviate these problems improved varieties introduced from Israel in 1983 and distributed to different parts of Ethiopia .In 2001/2002 a private farm called Green Focus ltd. introduced a new cultivar Alphanson from India to Loko Administrative kebele in Guto Gida district of East Wollega Zone of Oromia Region of Western Ethiopia (Temesgen, 2014). Many farmers grow mango for the source of food, income and shading purpose.

Mango suffers from different group of pests' i.e. powdery mildew, fruit flies, stem borer and scale insects.ect. Among the insect pests of mango, white mango scale are the important hard scale insects reported to have damaged mango in various part of the world (Germain *et al*., 2010, Emana *et al.,* 2015). These insect pests are called white mango scales (*Aulacaspis tubercularis) (Hemiptera)* is a serious pest in mango production at late cultivars (Emana *et al.*, 2015). The white mango scale is the tropical species that may have originated in Asia and it is mainly recorded in the host belonging to families: *Anacardeacae Palmae*, *Lauraceae and Rutaceae* particularly in mangoes in the world (Temesgen, 2014). In Ethiopia the white mango scale was recorded as *Aulacaspis tubrecularis* in Ambo Plant Protection Research Center with the aid of microscope from internet and the sample was sent to America in January 2011 for further confirmation by Ministry of Agriculture. Its common name is white mango scale,Hemiptera, Diaspididae *Aulacaspis tubercularis* Newstead and it was the first recorded in Ethiopia.

In the same way, in East Wollega Zone white mango is first recorded in 2010 in Green Focus Ethiopia private farm at Loko places in Guto Gida district (Temesgen, 2014 cited from Mohammed *et al.,* 2011).At the moment the infestation has spread to five districts at area of best producing mango like Gida Ayana,Guto Gida, Sasiga ,Limu and Diga and more than 33% of the mango area is infested by white mango scale. For this reason, the pest become now more serious and growing concern of all actors working with mango grower farmers in the area. This research was conducted to investigate the current status of the pest at Uke kebele of Guto Gida district of East Wollega Zone of Oromia Regional state and to study the impact of pest on the income of the local farmers of the kebele.

1.3 Objectives

1.3.1 General objective

To investigate the status of white mango scales in Uke kebele, the original place of the pest.

1.3 .2 Specific objectives:

1. To identify the current status white mango scale in Uke kebele.

2. To assess the existing capacities of farmers for pest management.

3. To investigate the effects of the pests on the income of the local farmers.

1.4 Significance of the study

Mango is the most important fruit crop in the tropics and sub-tropics next to Citrus and Banana. It is consumed as a fresh fruit and different form of preparations for its high contents of sugars, vitamins, minerals and protein among others (Ofgaa, 2017).Mango suffers from different group of pests, white mango scale are the important hard scale insects first recorded in Ethiopia and infesting mangos are less marketable for export (Temesgen, 2014, Emana *et al*., 2015).Therefore this study can give a better insight to enrich the mango grower farmers and private agencies cultivating mango understanding the current infestation of white mango scales and its impacts and develop better management practices to increase the income obtained from the crops.

Chapter Two

2.1 Literature Review

2.1.1 General overview

Tropical and Sub-tropical fruits make a significant direct contribution to the subsistence of small-scale farmers by providing nutritious food that is often available when other agricultural crops have not yet been harvested (Takele, 2014) .Amee (2013) stated that mango is the king among tropical and subtropical fruits and is greatly needed for its succulence, exotic flavor and delicious taste in most countries in the world.

Mango is a tropical and sub-tropical evergreen tree native to Indian subcontinent more likely in Burma-Malaysia region. Samra *et al.*, (2008) stated that fruits are man's oldest food and their importance in human diet is universally recognized and their produces is the mainstay of large number of people of India. It also depicted, even in the sculpture work in India. Following India in volume of production, China produces 3673 mt, Thailand produces 1800 mt, Mexico produces 1679 mt, Pakistan produces 1674 mt, Indonesia produces1478 mt, Brazil produces 1000 mt and Philippines produces 985 mt. Nigeria is the first in Africa followed by Egypt in terms of mango production and world production of mango is estimated to 45.22 million tons with a production area of 5.64 million hectares (Tsegaye *et al.,* 2017).Mango production is proceeded by citrus and banana. It is consumed as fresh fruit and different form of preparations for its high contents of sugars, vitamins, minerals, proteins and others (Ofgaa, 2017). Mango has become naturalized and adapted throughout tropics and sub-tropics in conjunction with the spread of human populations and its tolerance to a wide range of climatic conditions. A ripe mango fruit is subsistence and a fundamental source of nutrition for rural populations and rich in vitamins and minerals necessary for proper functioning and development of human body (Sarma *et al.,* 2008**,** Takele, 2014 cited from Vayssières *et al.,* 2012). Mango tree is successfully cultivated under very hot, humid to cool and dry conditions. It requires a mean annual rainfall between 400mm and 3600mm. It is indicated that mango grow very well at altitudes ranging from sea level to 1200 m.a.s.l with evident decline in production with increase in altitudes. Pertaining to its global demand, mango could play a significant role in foreign currency generation, and accordingly, its production has been on rise from time to time (Ofgaa, 2017).

Mango is also used as animal feeds and known to play a vital role in export and import business and hence generate foreign currency. Sarma *et al.,* (2008) pointed out that every year substantial foreign exchange is earned via export of fruits and their preparations. Marketing fresh and processed products generates income which can act as an economic buffer and seasonal safety net for poor households and diversification into fruit production can generate employment and enable small scale farmers to begin on a range of production, processing and marketing activities to complement existing income generating activities. Mango possesses anti-diabetic, antioxidant, anti-parasitic and anti-inflammatory properties and preferred for its high pleasant aroma and high nutritional value and as Jongen (2002) stated that regular consumption of fruit diet can also decrease the risk of being caused by chronic disease like cancers and so high consumption of fruit and vegetable is amendable to minimize the risk of being caused by cancer.

Among the fruits cultivated in Ethiopia mango is preceded in importance only by citrus and banana (Tesfaye *et al.,* 2014).The area under mango production in different regions of Ethiopia is about 3789.47 ha in Oromia, 3375.89ha in SNNPR, 652.56ha in Benishangu-Gumuz, 246.85 ha in Amhara, 180.41ha in Gambella, 44.5 ha in Dire Dawa, 33.52 ha in Somali, 118.20 ha in Tigrayi and 367.24 ha in Harari. The total area allocated for mango is about 8,808.64 ha and the country annual production of mango from all mango grower regions is about 697,507 quintals (Temesgen cited from (CSA, 2012/2013).

The mango tree in Ethiopia is developed from seedlings and is inferior in productivity and quality. To solve these problems improved varieties named Kent Keit and Tommy Atkims were introduced from Israel in 1983 and are being commercially produced and distributed to different parts of Ethiopia by the Upper Awash Agro Industry Enterprise (UAAIE) .In 2001/2002 a private farm called Green Focus ltd introduced a new mango cultivar called Alphanson from India and planted on its farm at Loko Administrative kebele in Guto Gida district of East Wollega Zone,Oromia Region of Western Ethiopia (Temesgen,2014).Many farmers grow mango for food, income and shading purpose. Mango is considered as an important element in a certain sociological aspect in some parts of Ethiopia. In Benishangul-Gumuz Regional state in particular, and other parts of Western Ethiopia, in general mango tree is used as a shade for livestock and conference hall for local people during hot weather conditions (Ofgaa, 2017).

Mango suffers from several diseases at all stages of its development. Richard (2005) said that nearly all plant structures are fed by insect pests and the most obvious symptom of insect feeding can be seen when the leaf is infested. All parts of the plants: trunk, branches, leaves, petiole, flower and fruit are attacked by insect pests. Mango seedlings were found to damage by pests with high incidence occurrence in July-October (Sarma *et al.*, 2008). Among the insect pests infesting mango white mango scale, *Aulacaspis tubercularis Newstead* is one of the agriculturally important devastating insect pests belonging to the order Hemiptera and characterized by having a piercing and sucking mouthparts and, it causes fatal damage especially by sucking leaves which turn pale-green or yellow and ultimately die or fruit causing conspicuous pink blemishes around insect feeding sites resulting in external lesions rendering it unmarketable for export (Abo-Shanab *et al.*, 2012). Recently, it becomes a serious on mango in all mango orchards in many countries (Tsegaye *et al.*, 2017) .Extensive planting of a single crops i.e. monocultures favors the rapid population growth of phytophagous insects (Howell *et al.*, 1978). This insect pest affects the production and expansion of mango in Ethiopia. Post-harvest physiology and storage of tropical and subtropical fruits are very important (Mitra *et al.*, 2005).

2.1.2 Mango production in Ethiopia

Among the fruits cultivated in Ethiopia, mango is preceded in importance only by citrus and banana. Mango is one of the most important income-generating fruit in the rural communities of Western Oromia and contributes to the county's economy through feeding the local communities, ecological balance and foreign exchange earnings (Duressa, 2018). The mango industry in Ethiopia is in its infant stage. However, mango is grown in different parts, especially in the Rift valley, Western and Southern parts of the country. Realizing the importance of agricultural diversification, increasing attention has been given to improving the horticulture sector in Ethiopia and experiences from other countries in growing this crop will therefore contribute to the success and wide spread use of the fruit (Takele, 2014, Gashawbeza *et al.*, 2015). Mango is traditionally grown in Ethiopia for family consumption and local markets, but some emerging modern farms have started to produce mango for local and export markets. Ethiopia exports mango to Djibouti, Saudi Arabia, Yemen, Sudan and Arab Emirates and the export share of mango from Ethiopia was reported to have been very small pertaining to low quality and productivity (Ofgaa, 2017). Upper Awash Agro Industry Enterprise (UAAIE) and Raj Agro PLC are among modern farms producing fruits at a relatively larger scale. Very limited companies is producing fruit juices in Ethiopia of which a juice

producing company is found in Sebeta 24 km Southwest of Addis Ababa (Ofgaa, 2017). Mango in Ethiopia is developed from seedlings and is inferior in productivity and quality. The main abiotic factors contributing to low mango production and quality are water stress, extreme summer and winter temperatures, soil salinity and nutritional deficiencies particularly Mn,Fe and Zn(Masood *et al.*,2010).

The mangos commonly grown in Ethiopia are local varieties and are known for their fibrous feature which limits processing and marketable acceptance and by the efforts of Ethiopian Agricultural Research Organization (EARO), new varieties of mango such as Tommy Atkims, Apple mango, Kent and Keit have been introduced and were under production .Similarly, a Green Focus Ethiopian ltd introduced a new mango cultivar Alphanso from India in 2001/02 to Loko in Guto Gida district of East Wollega Zone (Plate2.1). Many farmers grow mango for food, income generation and shading purpose. Mango is considered as an important element in a certain sociological aspect in some parts of Ethiopia, especially in Benishangul-Gumuze Regional State in particular, and other parts of western Ethiopia, in general ,mango tree is used as a shade for livestock and conference hall for local people during hot and weather conditions(Ofgaa,2017. These trees play vital role in maintaining ecological balance as old mango varieties at Hanger Megersa (Plate 2.2) and thus indispensable for mankind (Sarma *et al.*, 2008).

2.1.3 Distributions of White Mango Scales.

White mango scale is distributed in a wide range of climates (Temesgen, 2014) and now widely spread in mango growing countries. It is a tropical species originated in Asia and has been firstly reported in India (Tesfaye *et al.*, l2014). The population density of white mango scale was formerly recorded in few parts of the world. However, it has been spread by the transport of infested plant materials and winded its scope and has become an important mango pest in many mango growing countries including Florida in USA, Brazil, Jamaica, Colombia, West Africa, Caribbean, Egypt, Ghana and Kenya (Abo-Shanab 2012, Emana *et al*, 2015). The detection of white mango scale on mango entering Pakistan was recognized with the importation of infected mango fruits to the United Kingdom and Temesgen (2014) stated that post harvest cleaning and washing will not remove all the scales and quality control inspectors within the packing in the house may miss some infested fruit.

The pest has not been recorded in most of the tropical pacific Islands and international Institute of Entomology and it became an economic pest all over Egypt after it was restricted in Minia Governorate under quarantine regulations then crept to Beni-Suif Governorate, so, population fluctuations and role of its natural enemies in regulating its abundance have not wide studied till now in Egypt(Egyptian academic @ hayoo.com).The introduction of insect pests, plant diseases and other pest is associated with the commodity brought mainly during accelerated agricultural development in different countries, when plants and plant materials were transported with no concern for the insect pests and diseases. Due to import of mangoes with tropical and sub-tropical countries of the world, the possibility of pest introduction along the commodity remains a threat (www.bioone.org).Mango cultivation in the world is expanding due to the popularity and ever-increasing demand for fresh and processed products and a profitable mango industry depends on the production capacity of the trees.

White mango scale is a serious pest of mango posing fatal damage to late maturing and ripening stage of the fruit may be because matured and ripe mango fruits posses more aroma which could be used to attract white mango scale and sucking causes conspicuous pink blemishes around inset feeding sites and rendering the fruit less marketable for local and export market (Bissdorf, 2005, Emana *et al*., 2015). Damage occurs in myriad way. Most conspicuous is defoliation of plants caused by sucking of the insect resulting in loss of large quantities of leaves or twigs. Sucking insect removes plant juices, some poison the plant or transmit various diseases to organisms and reducing the number of these pest species to a point of eliminating or preventing material losses has been and still is one of the primary objectives of applied entomology (Harbert *et al.,* 1991).It is the most important hard scale insect which is reported to have damaged mango in various parts of the world (Ofgaa and Emana (http//www.iiste.org).

The insect pest can nibbled off the fruit quite easily and the highest infestation occurred on the shady regions of the tree (Ofgaa, Emana and Ruth, 2017). Labuschagne *et al.,(*1995) stated that although the mango scale does not cause internal fruit damage, its cosmetic effect on the fruit skin result a significant decrease in exportable potential of the fruit and substantial financial losses of mango growers and it is so important to control insects pests before they settle on the fruit, even if they are killed on the fruit, the injury remains on the fruits affect the fruit quality. White mango scale is the first recorded incidence of mango in South Africa and currently posing severe threat to

mango plantations in various mango growing countries (Labuschange *et al.*, 1995, Germain *et al*., 2010, Tesfaye *et al.*, 2014, Emana *et al*., 2015).

In Ethiopia, white mango scale was identified as *Aulacaspis tubercularis* in Ambo Plant Protection Research Center with the aid of microscope from internet and the sample was sent to America in January 2011 for further confirmation by the Ministry of Agriculture. In the same way, in East Wollega zone of Oromia Regional State of Western Ethiopia, the white mango scale is first recorded in 2010 in Guto Gida district in Green Focus Private Farm at Loko Administrative kebele. At the moment infestation was recorded from five districts producing mango which include Gida Ayana, Sasiga, Sibu Sire,Limu and Diga and more than 33% of the mango producing area are infested by this insect pests (Temesgen and Tesfaye *et al.*,2014).From the above points one can judge that the insect pest invaded the East Wollega and spread to mango producing districts from the mango which is planted at Loko farm land by Green Focus. This study is aimed to assess the current status of the pest at Uke kebele of Guto Gida district.

Plate2.1 Mango Plantation at Loko Farm(Green Focus)

Plate 2.2 Mango plantation at Anger Megersa(old variety)

2.1.4 White mango scale Symptoms on Mango

The pest's damage symptoms are many, but the major ones include wilt, stunt, distort and bleach without loss of solid plant tissues (Alka, 2001).White mango scale injures mangoes by feeding on plant sap in the leaves, branches, and fruits causing defoliation, drying up of twigs, poor blossoming and hence affects commercial value of the fruit quality below export requirements (Abo-Shanab, 2012, Pablo, 2014). The nymph and the adult scales suck the sap of the leaves and other tender parts and reduce the vigour of the plant and they are noxious to the plant (Stocks, 1991). The sap which the pest sucks from the plant provides essential elements for growth and the pest suck it actively during summer (Vyas, 2005). In nurseries, severe early stage infestation retard growth because, the seedling tissues are sensitive to damage on its meristematic regions and young trees are particularly vulnerable to excessive leaf loss and death of twigs during hot and dry weather.

The feeding Hemiptera often recognized as small discolored spots where the inner palisade and spongy mesophyll cells broken down and emptied. The insect has physiological effects on the leaf which are also injurious and the secretion of the insects stimulates abnormal development of growing plant resulting in misshapen leaves or swellings (Howell *et al.,* 1978). The heavily infected

premature fruit dropping and the mature fruit become small in size and juice less because the pests suck the sap contents providing essential nutrients for growth. WMS inserts its stylets and feeds on sap from fruits, leaves, twigs ,it robs high level of nutrient exploring potential of mango and can pierce cell walls, even the lignified secondary walls of xylem by the of styles bundles resulting in severe damage to the crop (Plate 2.3) (Ofgaa ,2016). Pertaining to feeding habitat of the pest, the damage caused to mango plantation includes yellowing of leaves, development of conspicuous pink blemishes on mature and ripe fruit and die back of twigs(Emana *et al.*,2015,Ofgaa,2016).Insect cause wounds on plant organs (leaves, root, fruit, shoots, branches) on which they feed or deposit their eggs (George, 2004). This pest is currently posing sever threat to mango plantations in various mango growing countries (Labuschagne *et al.*, 1995). Infestation in young trees may lead to excessive fall off leaves, retarded growth and death of whole plants (Ofgaa, 2016 cited from Nabil *et al.*, 2012). White mango scale is tropical species that may have originated in Asia and mainly recorded in hosts belonging to four plant families:*Anacardeacae Palmae, Lauraceae and Rutaceae* particularly in mangoes and cinnamon in the world (Abo-Shanab, 2012 cited from Brochsenius, 1996; Temesgen, 2014 ,Ofgaa, 2015).White mango scale is a phytoyphagous pest which feeds on many plant species, even though it is a serious pests of mango and among insect pests inflicting damage to mango.

Plate 2.3.Change in colour and wilting of mango leaves by white mango scales at Uke

2.1.5 The Current Status of the pests

White mango scale, is currently a wide spread pest throughout all mango producing areas in South Africa (Labuschage *et al.*,1995).Under present system of monoculture, the presence and activity of pest species is inevitable and importation of high yield, but genetically improved cultivars into new areas of high pest susceptibility, high use of fertilizers, and other chemicals, and irrigation practices have produced many pest problems that were not present on the typical early small farm that used only plants and their seeds that had survived pest infestation and transportation has also become increasingly refined and crops marketed worldwide resulting in pests becoming translocated into new area(Richard,2005).Due to global agriculture and trade coupled with poor quarantine regulation introduction of new disease and insect pests to Ethiopia has become a common phenomenon (Gashwbeza *et al.,* 2015).White mango scale does not cause internal fruit damage but ,its cosmetic effect on the fruit skin significantly decrease the export potential of fruit and substantial financial losses of the mango growers (Labuschage *et al.,* 1995, Salem *et al.,* 2015).

The new pest causing damage to mango was reported in 2010 in an orchard of the Indian Company Green Focus Ethiopia in Western Ethiopia (Temesgen, 2014,Emana *et al.*,2015).The pest could have been most likely introduced to the Ethiopia accidentally from abroad with mango seedlings imported by the aforementioned Company. Following its initial record, infestation was reported in other mango farms in Western Ethiopia as far as 100 km away from site of the first record within one year (Ofgaa *et al.,* 2017). The pest has been transported most likely with fruits. Timothy *et al*. (2006) stated that the special distribution of the population is influenced to a considerable extent by anthropogenic activities that determines landscape structure and introduce intentionally or unintentionally commercial and pest species to new regions.

2.1.6 Management of White Mango Scale

Crops are damaged by the abundance of herbivores insect. Vast sums are expended to control insect pests, which can greatly reduce the agricultural yield necessary to support an exponentially expanding human population (Ruppert *et al.,* 2004).Pest management was aimed at the reduction of the pest problems by actions selected after the life system of the pests are understood and the ecological and economic consequences of these pests have been predicted, as accurately as possible, to be the best interests of humankind (Bayeh, 2016).

Like other phytophagous insects, white mango scale needs its host for food, ovipositor site and shelter. In the process of exploiting the host plant for food and ovipositor, it poses deleterious threats to the host plant which interferes with mango growers' interest and as a result the issue of management of the pest is necessary. Collecting tools and techniques are an important part of a pest management audits, regardless of the type of building or commodities stored or manufactured in the facility (Timothy *et al*., 2006).The outbreak for insect pest plague spread more and more often become a major concern of the forester the farmers of the public health custodian (Vyas, 2008).

For this reason pest management undertaken to clearly understand the degree of damage and permissible damage. This study includes economic injury level and economic threshold level. Economic injury level is the lowest post population density that what will cause economic damage. It is the level at which damage can no more tolerated and is desirable to initiate control operation (Vyas, 2008). The economic threshold level is the pest density at which control measures should be applied to prevent an increasing pest population from reaching the economic injury level (Vyas, 2008).The preparation of crop time tables provides a solid foundation for analysis of pest damage and cost benefits ratio in pest management. Unless, insect pests of Agricultures are not checked, it would be difficult to grow crops at all (Doyen *et al*., 1978). Accordingly, application of pest management in the field is essential to know the way how to manage pests (Vyas, 2008).

2.1.7 Biological Control

The control of plant pests by natural enemies termed biological control where population of an organism is kept in check by combination of physical and biotic factors. Biological control is the utilization of natural enemies to reduce the damage caused by noxious organisms (pests) to tolerable level. The number of biological agents have been used for white mango scale control and the role of predator beetle, *Cybocephalus binotatus* ,parasitoids *Cales noaki* (parasitic wasps),flies and predators (some insects, spiders and predatory mites) and pathogens (fungi, protozoa, bacteria and virus) was well known (Duressa, 2018). Ofgaa, (2016) identified that a native predatory beetle ,*Chilocorus sp* preying on white mango scale for the first time in Western Ethiopia which can provide a roadmap for designing biological control of white mango scale. Andrew *et al*., (2008) stated that predator such as ladybird beetles and green lacewings, and tiny parasitic wasps may be used to suppress scale insect population.

2.1.8 Cultural control

Reducing the number of pest species to a point of eliminating or preventing material losses has been and still is one of the primary objectives of applied entomology (Harbert *et al.*,1991).Cultural control involves manipulation of the environment to make it less favorable for the pest population. These may include crop rotation to minimize damage by pest, timing of planting to the period when the insect is at least abundant or absent (Richard, 2005). Cultural pest control is a practice of manipulation of a garden's planting, growing and cultivation with the purpose of reducing pest number and its damage to the crop under consideration (Ofgaa,2017).In relation to control scale insects relevant cultural practices include pruning, smoking, area clearing of infected parts of the crops (Tesfaye *et al.*,2014).Temesgen(2014) stated that farmers in Ethiopia used pruning, smoking and area clearing as a cultural management practices to control white mango scale.

2.1.9 Chemical control

Insecticides of various types are used to control insect pests in agriculture. Pesticides are chemicals used to kill or repel or reduce pest damage (Ofgaa cited from Paul and Gupta, 1994). Insecticides are chemicals used to kill insects with no apparent or at least only minimal effects at the recommended dosage levels and conditions of usage (Richard, 2005).The use of chemicals or pesticides may give faster solution .Temesgen (2014) stated that Green Focus Ethiopia owing farm land at Loko Administrative kebele uses chemical insecticides Organophosphates to control white mango scale and the spray mechanism undertaken twice a year before the setting of the flower and after harvest.

2.1.10. The implication of the pest mango value chain

The concept of value chain encompasses organization, coordination, the strategies and the power relationship of different actors in the chain value refers to the full range of activities that are required to bring a product from conception, through the different phases of production, to delivery to final consumers and disposal after use. Further, a value chain exists when all the stakeholders in the chain operate in the way to maximize the generation of the value along the chain (Takele, 2014).

Value chain also includes the range of activities performed within a firm to produce a certain output to bring a raw material to the retail of financial product and agricultural inputs are important

elements for production and productivity. As a result, the typical inputs utilized for production of mango was seed/seedling, labor, land and compost.

The major sources of inputs for production of mango in Ethiopia are farmers, agricultural office and markets (Takele, 2014).In the context of increasing the high value production of agricultural commodities, fruit trees and perennial crops play an important role and expansion of state farms in the past command economy and the prevailing expansion of private sectors in different regions of the country have contributed a lot on the introduction of fruits as business. In Ethiopia, mango consumption is largely in its fresh form due to the fact that the cost increment for processing and packaging would make it beyond the purchasing power of the vast majority of Ethiopian consumers. But, currently the fruit has a significant importance with the potential of domestic and exports and industrial processing. The crop is being promoted by the fruit and vegetables and Horticulture in its program to support business organization and their access to marketing (Takele, 2014).

The production, marketing and consumption of mango fruits are restricted due to improper handling, inadequate transport and storage facility, disease problems and sensitivity to low temperature and growing and marketing of fresh fruit like mango in Ethiopia are complicated by post-harvest losses both in terms of quality and quantity(Mitra *et al*., 2005).In the same way, in East Wollega,Uke kebele, majority of mango producers sell their products at nearby local markets and mostly to consumers and sometimes to retailers because of the market fluctuation and lack of marketing infrastructures and the emergence of the pest has become a stumbling block to realize the objectives of mango value chain project at East Wollega of Uke kebele producing mango and hence it reduces the market opportunities, qualities and productivities of the owners of the mango of the farmers cultivating mango. This emerging pest impairs the sustainable utilization obtained from mango fruits for improved economic development through improvement of families in food security by promoting improvement in livelihoods. For this reason, to improve mango value chain project and increase the quality and productivity of mango for marketing, the impacts of the pest should be keep in to consideration in all areas of mango cultivating of the kebele. Management practice of the pest is so important for sustainable production and utilization of the fruits in the uke kebele.

Chapter Three

3.1 Materials and Methods

3.1.1 Description of the study area

The study was conducted in Uke kebele of Guto Gida district East Wollega Zone of Oromia Regional State (Fig.3.1). Uke kebele is located at $09^{O}19.226$'N and $036^{O}31.619$'E in East Wollega(Fig.3.2) at a distance of 35km from the capital city of the Zone, Nekemte town and 370km far away from Addis Ababa to the west. The study was conducted on mango orchard of Green Focus. The orchard size was 2276 hectares. The altitude of the area is ranging from 1200-1799m a.s.l. The mango orchard of Green Focus was planted 15 years ago. The mangos were from 12-15 m tall and spread at a distance of 2m from each other on average .Uke (Fig.3.3) received a mean annual rainfall of 1841mm.Coordinates of the study area were recorded using GPs and Map of the study area was plotted Using GIS soft ware.

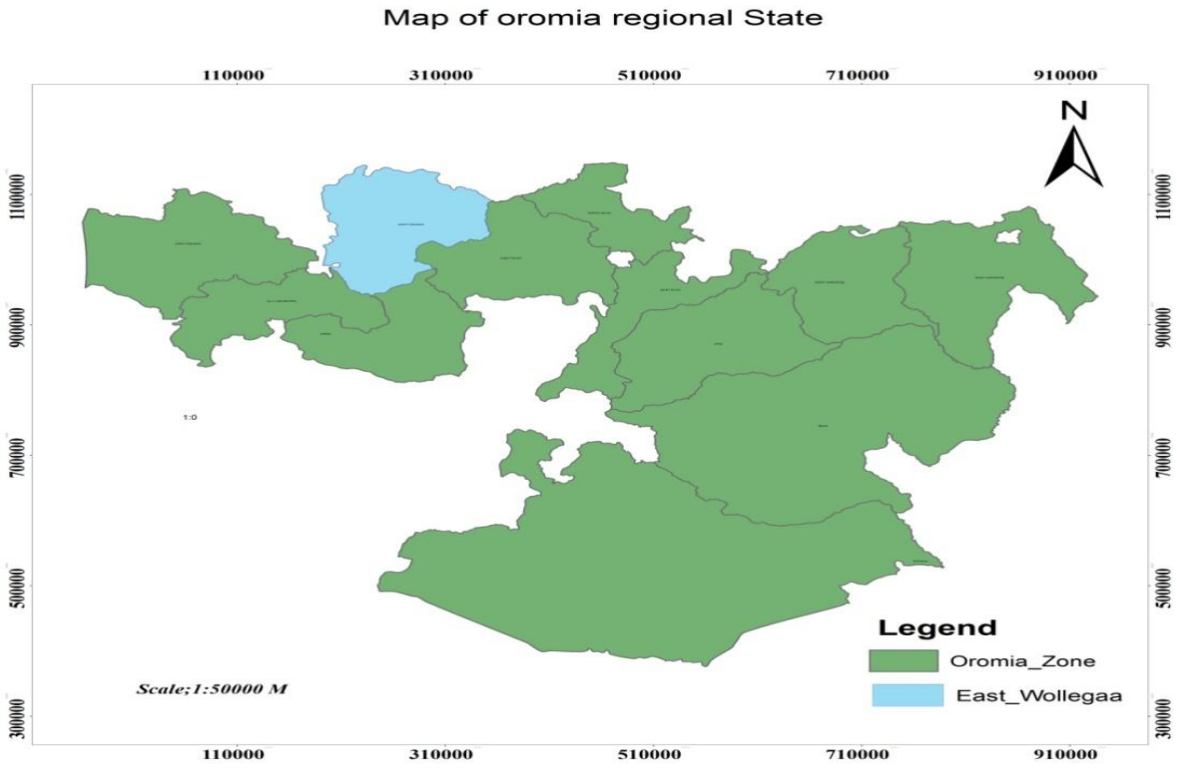

Figure 3.1 Map of Oromia Region

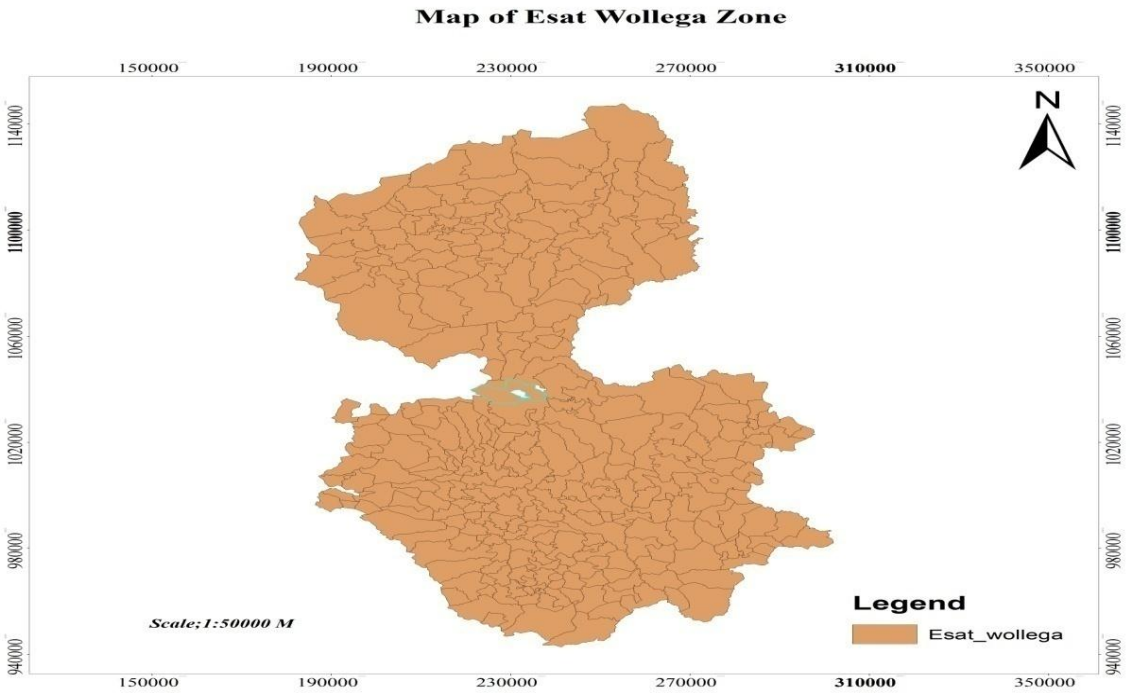

Figure 3.2 Map of East Wollega

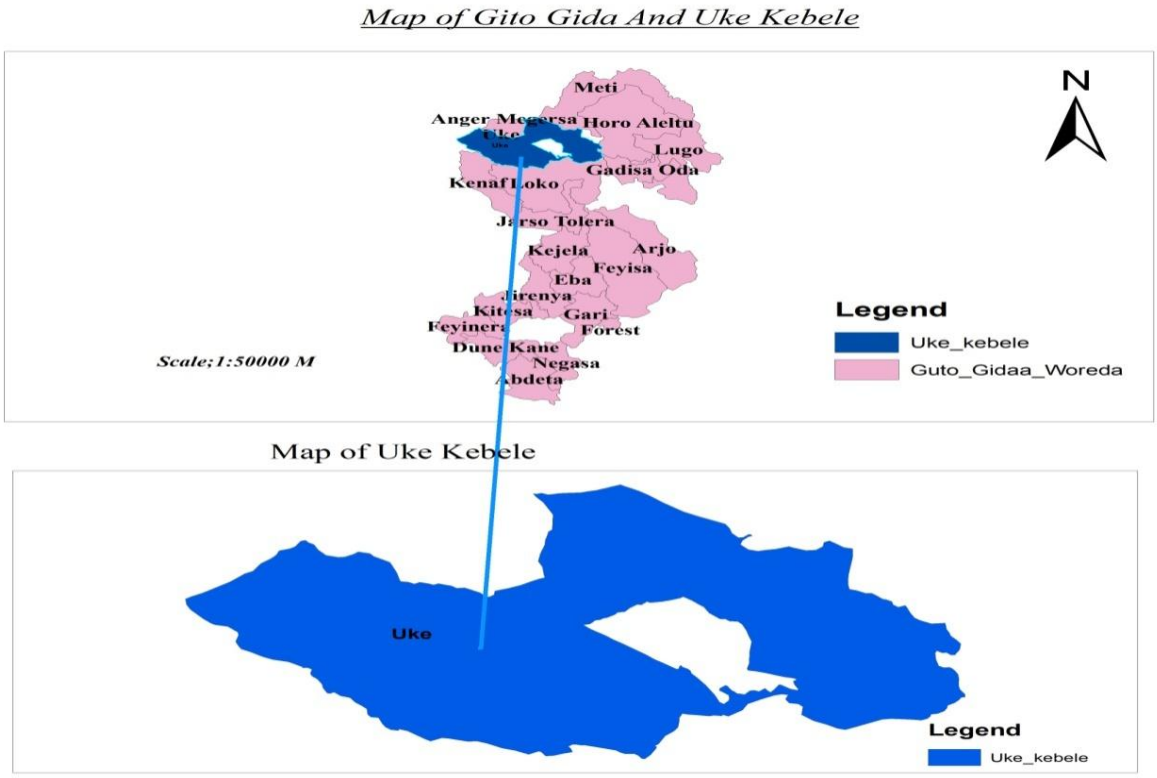

Figure 3.3 Map of Guto Gida and Uke kebeles

Type and Source of Data

Both relevant qualitative and quantitative data were collected from primary and secondary sources. The primary data for qualitative study were collected from farmers who have adequate information and knowledge about white mango scale. The knowledge and information of these people include sources of mango seedling, knowledge about the insect, impact of the pest on their annual income, management practices farmers use for the management of white mango scale and other insects/diseases attacking mango. Secondary data for quantitative traits such as description of the study area, topography, climate, were taken from Agricultural Office.

Method of Data Collection and Sampling Procedures

The study sites were selected purposively based on the extent of mango production and the nature of the farm. For the study, 80 farmers were purposively selected for the study based on the extent of knowledge on mango trees they have and their experience in mango production. The mango farm at a series of spots within the intervals of 5km to 35km distance was considered for sampling purpose from its first origin of infestation. The data was collected randomly from January 15/5/2010 to June 15/10/2010 from the orchard of Green focus and Questionnaire was distributed for purposively sampled population. The result of study showed that high population peaks of WMS was recorded and distributed from its original point with high and very high infestations across district and kebeles in km.

3.1.2 Data collection tools

3.1.3 Questionnaire and Interview

Questionnaire was employed to collect quantitative and qualitative data from selected farmers. The questionnaire was prepared in English and translated to Afan Oromo for respondent farmers. Mango production in Uke is annual. It occurs once in a year and the peak harvest is in March to May and hence, the data was collected before mango harvesting season. Through structured questionnaires by posing direct and information seeking open ended questions to the interviewer, qualitative and quantitative data were collected from the farmers. Information about their experience in mango production, distribution, severity status and management practices of the farmers in the past and present situation of the pest were collected from sampled mango grower farmers and an interview was made for the Head of Agricultural Office of the district.

Chapter Four

4.1 Results and Discussions

4.1.1 Survey on farmers' knowledge and management practices of white mango scales

4.1.2 Demographic Characteristics of the respondents

From the total number of participants considered for questionnaires, the response rate obtained was 100 %(n=80). From the total respondents 90% were male and most of the participants were married (Table, 4.1)

Table 4.1 Sex ratio of the respondents

Sex	Frequency	% response
Male	72	90
Female	8	10
Total	80	100

Age structure of the respondents showed that about 45(56.25%) were between 36-40 years old, 14(17.5%) were between 26-35 years old and 12(17.5%) were between 41-56 years old, 7(8.75%) were below 25 years old, 2(2.5%) were between 57-61 years old (Table 4.2)

Table 4.2 Age structure of the respondents in Uke administrative kebele

Age group in year	Frequency	%response
Below 25	7	8.75
26-35	14	17.5
36-40	45	56.25
41-56	12	15
57-61	2	2.5
Above 62	-	-
Total	80	100

Information obtained from the respondents demonstrated that 51(63.75%) of the participants have attended basic education, of which 12(15%) have attended high school and 8(10%) have completed high school 9(11.25%) have never attended school (Table, 4.3)

Table 4.3 Education background of the respondents in Uke

Items/variables	Frequency	%response
Never attended school	9	11.25
Attended primary school	51	63.75
Attended 2^{nry} school	12	15
Completed high school	8	10
Total	80	100

4.1.3 Mango production and farmers experience about white mango scale in Uke

Information gained from the participants showed that mango production is a common farming practice in Uke kebele and from the respondents 49(61.3%) of them was informed that they have practiced in mango production for 10-20 years ,where 17(21.25%) of them have an experience of mango production for about 21-30 years and 8(10%) and 6(7.5%) of them have an experience of mango production in between less than 10 and greater than 31 years respectively (Table ,4.4).The respondents was replied in open-ended questions what kind of mango the cultivate, and that they were familiar in planting the pre-existing old varieties of mango and they call it habesha mango. Preferences for mango varieties for local consumptions and commercially exports are very crucial. Kassu (2009) stated that knowledge continuously involves as farmers learn both by evaluating the outcome of the previous and by observing the environment.

Table 4.4 farmer's knowledge of mango production

Variables in years	Frequency	Percentage
Less than 10	8	10
10-20	49	61.25
21-30	17	21.25
Greater than 31	6	7.5
Total	80	100

About 65% of the total respondents didn't know the insect pest and only 35% of them knew the insect pest infecting their mango. Those who knew the insect pest 96.3% of them said that their experience where less than 10 years and 3.8 of them replied their experience were 20 years. The

respondents have also asked to mention the major damage that it caused to their mango and said that it dries its leaf, infect the fruits and make it less marketable. *Aulacaspis tubercularis* injures the leaves and fruits, affecting the commercial value of the fruit and export potential (Salem *et al.*, 2015) (Table 4.5)

Table 4.5 Effectiveness of the controlling methods

Valid	Frequency	Percentage
Yes	28	35
No	52	65
Total	80	100

The participants were asked to inform whether the damages caused by the insect pests on their mango as it affects their income or not and almost all respondents 100% replied that the infestation decreases the quality of the fruit and less acceptable for market, hence, decrease their annual income. Labuschagne *et al., (*1995) stated that mango scale does not cause internal fruit damage, its cosmetic effect on the fruit skin result in a significant decrease in exportable fruit and substantial financial losses of the mango grower and it is utmost important to control the scale insects before they settle on the fruit.

Among the respondents 51.2% of them said that the leaf part of the plant was infected first and the infestation slightly go to the fruits and the branches 26.3% and 22.5% respectively as in (Table 4.6) below. White mango scale causes fatal damage to late maturing and ripening stage of the fruit may because matured and ripe mango fruits posses more aromatic which could be used to attract white mango scale and sucking result in conspicuous pink blemishes around insect feeding sites and rendering the fruit unmarketable for local market and export (George, 2004, Bissdorf, 2005, Abo-Shanab 2012, Emana *et al*., 2015).

The respondents were described that the symptoms seen first it dry the leaf and then gradually it goes to branches and finally it make the drop off the early flower and passed to unripe fruits. The farmers said the pest was infecting the improved mango varieties and the local mango plants equally. Observations from the survey indicated that the pest causes premature drop of leaves, dieback of twigs and branches, stunting and distortion of fruits, drop of unripe fruit and the fruit

attacked by this insect pest become less marketable because of low quality. It can be clearly seen that from (Figure.4.1) white mango scale infestation on mango fruits on sale Anger Gute bus station which is reduced in quality and below export requirement.

Table 4.6 Respondents response to parts of mango trees get infested first

Valid	Frequency	Percentage
Leaves	41	51.2
Fruits	21	26.3
Branches	18	22.5
Total	80	100

Figure.4.1 Infected Mango fruits on sale at Anger Gute bus station

Of the respondents 63.7% of them said that currently the status of the infestation was very high and 23.8 % and 12.5% of the respondents replied that the infestation was high and moderate respectively as indicated by the following Figure 4.2 The survey revealed that all sampled kebeles was infected with white mango scale even though the level of infestation was varied apart from the first location of the pest. White mango scale infestation level was high at ripe and maturity stage of the fruit may be because matured and ripe fruit posses more aromatic which could be used attract white mango scale (Emana,*et al.*,2015).

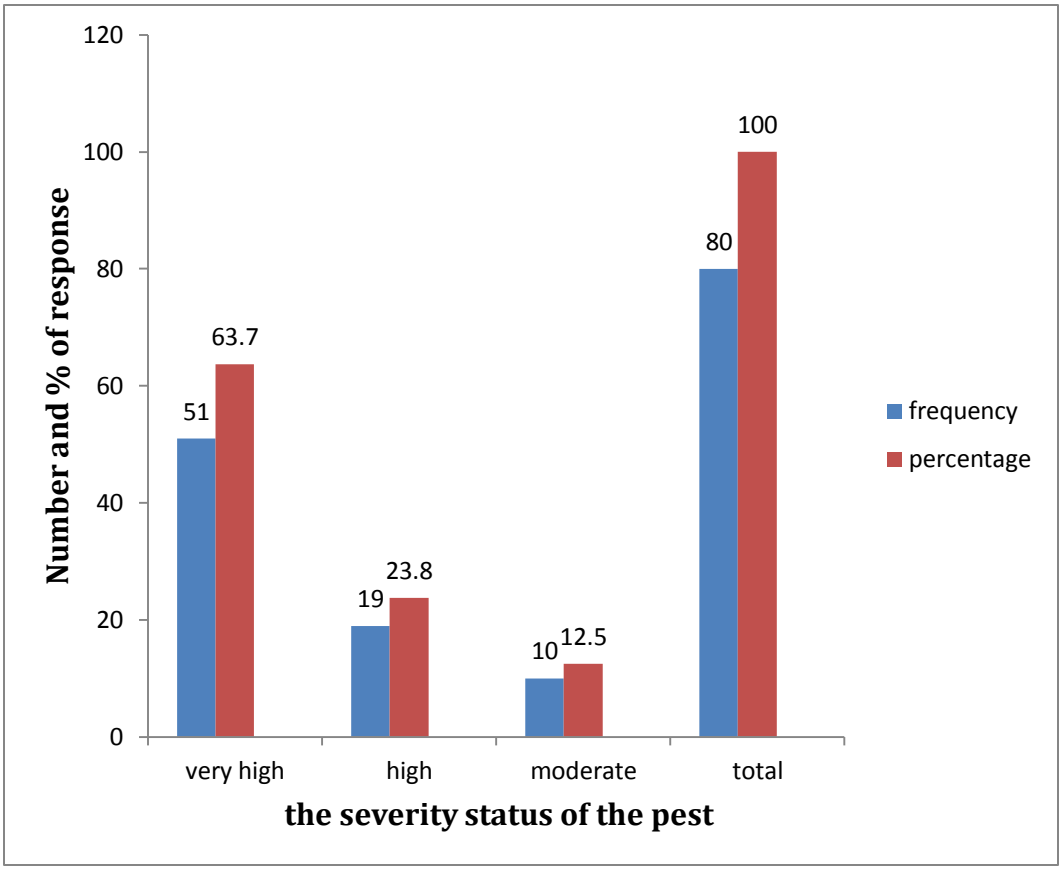

Figure 4.2 Graph showing the current status of the pests

4.1.4 Management practices of white mango scales in Uke

From the total number of the respondents, about 72.5% of them attempted to control the white mango scale used cultural, 18.8% used chemical methods and 8.8% preferred to have used both cultural and chemical methods as possible (Figure.4.3). The major actions they take to control the pests by cultural methods include activities like pruning of heavily infected branches, smoke under the mango plant using the fallen mango leaves ,grasses and animal dung within the mango tree area to chases the insects away from the tree and, area clearing and grafting. Cultural control involves manipulation of the environment to make it less favorable for the pest population. These may include crop rotation to minimize damage by pest, timings of plantings to the period when the insect is at least abundant or absent (Richard J, 2005). These may include crop rotation to minimize damage by pest, timings of plantings to the period when the insect is at least abundant or absent (Richard, 2005). Pest management was aimed at the reduction of the pest problems by actions selected after the life system of the pests are understood and the ecological and economic consequences of these pests have been predicted, as accurately as possible, to be the best interests of humankind (Bayeh,2016).

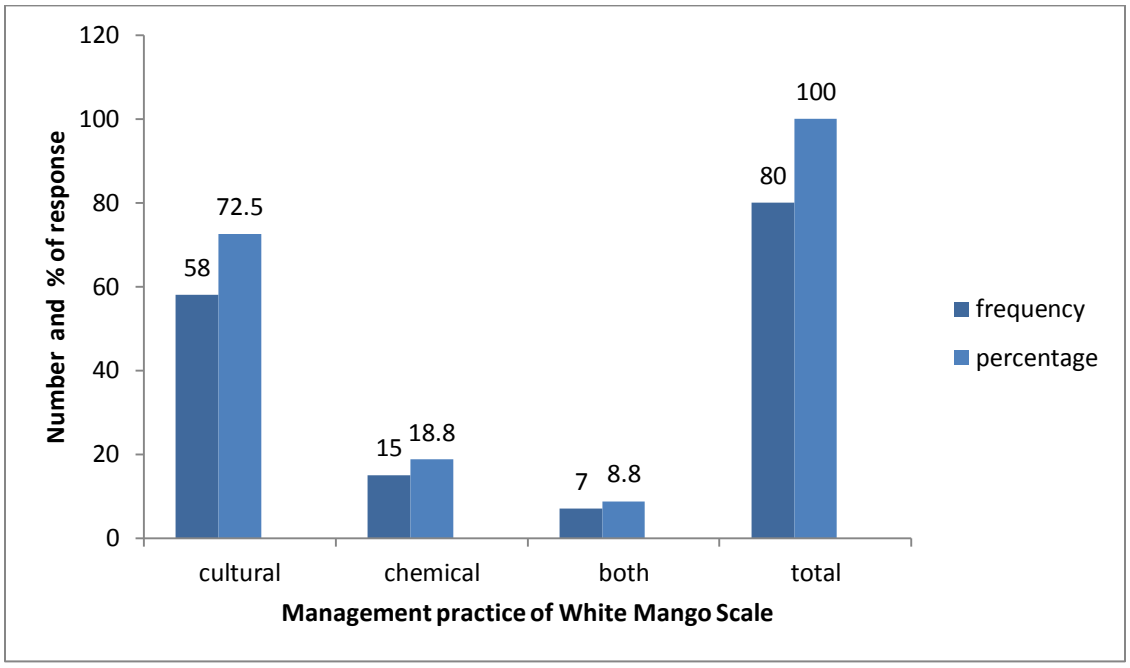

Figure 4.3 Graph showing management practices of white mango scale

From the total population, 57.5% of the respondents said that the method employed to control the pests was not efficient where as 31.3% mentioned that the method used was efficient to some extent to control the pest and 11.3% said it was efficient to control the pests as indicated in Table 4.7.The participant farmers were also asked to elucidate whether they have an external support to control the pests and they mentioned that as an awareness was given to them from Government through training at Farmer Training Center by trainee.

Table 4.7 Responses of respondents on effectiveness control methods of white mango scale

Valid	Frequency	Percentage
Yes	9	11.3
No	46	57.5
To some extent	25	31.3
Total	80	100

4.1.5 Distribution or Spread of white mango scale

The white mango scale is distributed in a wide range of climates (Temesgen, 2014) and now widely spread in mango growing countries. It is a tropical species originated in Asia and White mango scale has been firstly reported in India (Tesfaye *et al.,* 2014). It has been spread by the transport of infected plant material and now widespread in many mango growing countries including the USA (Florida), Northern part of South America (Brazil, Jamaica and Colombia) ,East and West Coasts of Africa (Egypt, Ghana and Kenya). (Labuschange *et al.,* 1995, Germain *et al*., Abo-Shanab 2012, 2010, Tesfaye *et al.,* 2014, Emana *et al*., 2015).White mango scale is the first recorded incidence of mango in South Africa and its entry to Pakistan was recognized by the transport of infected plant materials to the United Kingdom. Temesgen (2014) that is because post-harvest cleaning and washing will not remove all the scales and quality control inspectors within the packing in the house may miss some infested fruit.

In Ethiopia, white mango scale was identified in 2010 from Guto Gida district in Green Focus Private Farm at Loko Administrative kebele. At the moment white mango scale infestation was recorded from five districts producing mango which include Gida Ayana,Sasiga, Sibu Sire,Limu and Diga and more than 33% of the mango producing area are infested by this insect pests(Temesgen and Tesfaye *et al.*,2014 Emana *et al*.,2015). During the field survey the farmers nearby the Green Focus witnessed that they saw the pests for the first time on this farm land owned by the aforementioned private. The preliminary surveyed information about white mango scales has spread from Loko, the locus of first record to all mango growing neighboring kebeles of the district like Hanger Megersa, Jarso tolera ,Uke and Anger Gute in four directions.

An interview were also made for Guto Gida Agriculture Heads Ato Ayele Terefe (Figure4.4) on the distribution /spread severity status and management options provided for the farmers on white mango scale and responded that at the wereda level the kind of support provided for pest mango were giving the training at FTC to manage the pests with their indigenous cultural methods like clearing infected site smoking and pruning etc.

Figure 4.4 an Interview made at Guto Gida Agriculture Office

The flight capacity of the insect contributes for the success of its dispersal in any direction and insect dispersing in any direction have a higher probability to contact larger patches than smaller patches. White mango scales is a very small insect, less vigorous individuals tend to colonize more proximal habitats as compared to more vigorous individuals which can fly greater distance and colonize more remote habitats. From its first loci, Loko Green Focus white mango scale has distributed to mango growing of the district.

Data obtained from field survey (Table, 4.8) showed that the maximum air distance covered by white mango scale was 35km to the west of Uke, Anger Gute from its first origin of infestation in the district and it can be concluded that white mango scale is becoming the most important limiting factor of mango production in the study area, even in the Eastern part of Wollega Zone. The dispersal rate is alarming indicating that within a short period of time the pest can invade the whole mango growing areas of the Wollega Zone particularly Guto Gida district.

Table 4.8 white mango scale distribution from its original infestation across district and kebeles in km

White mango scale original infestation place			White mango scale distribution or arrival to district and kebele		
Administrative kebele	District	Direction	District	Kebele	Distributionair distance in km.
Loko kebele	Guto Gida	North	Guto Gida	Uke farmers	6.5
Loko kebele	Guto Gida	West	Gida Ayana	Ange gute/gutin	35
Loko kebele	Guto Gida	South–west	Guto Gida	Hanger megersa	8
Loko kebele	Guto Gida	East	Guto Gida	Jarsotolersa	7

4.1.6 Severity status of white mango scale within the district and the neighboring district's kebele

Severity status of white mango scale in mango orchards was studied in Uke kebele by taking samples from its original infestation across district and kebeles. To indicate the severity status of white mango scale, even though the twigs and fruits of mango are attacked by this insect pest, only clusters formed on leaves were counted .Data analysis of the survey showed that the severity of infestation varied from moderate, high and very high across the district and kebeles.

From the data obtained clusters formed by the white mango scales per leaf indicated that the highest peak of infestation occurred at Uke and Jarso tolera kebele with a mean average of 15.2 and 13.4 clusters per leaf with air distance of 6.5 and 7km from the first Loci of the pests, Loko Green focus farm land respectively. Two high peaks occurred in Hanger Megersa and Anger Gute at air distance of 8 and 35 km with a mean average of 12.4 and 10.2 clusters per leaf respectively. The population of white mango scales started building up in January, February and March at the moment of the onset of the Autumn and gradually begins to decrease May, June and July in populations because the rain fall washed away from mango trees it inhabited .Ofgaa, (2017) that the scale insect population abundance is affected by rain.

4.1.7 Distribution and Severity Comparison between sampled district and kebeles

As white mango scale emerged in Guto Gida district ,Loko kebele,it is true that the chance of the adjacent district or kebeles to be infested by this pest is high, since white mango scale can move with the help of external forces like wind ,birds and insect pests and with infected seedlings(Temesgen,2014,Duressa,2018).The survey revealed that there was no kebeles infected with white mango scale even though their level of infestation was varied apart from the first location of the pest.

Chapter Five

5.1 Conclusion and Recommendations

5.1.1 Conclusion

Mango is one of the most important income-generating fruit tree in the rural communities and its production in Uke is annual with the peak harvest in March to May and mango producers sell their products at nearby local markets and mostly to consumers and sometimes to retailers.

Mango suffers from several diseases and all plant structures including: trunk, branches, leaves, petiole, flower and fruit are attached by insect pests. Mango production in Uke is constrained by white mango scale reported in 2010 from Green Focus in Western Ethiopia.The study revealed that from the sampled kebele white mango scale reached and infested all mango growing kebeles with varied degree of infestation. Therefore, it can be concluded that the rate at which white mango scale has spread in all mango growing kebeles is a reminder that the status of this insect pest has become beyond internal, although it is a new insect pest in the Uke kebele.

It was concluded that white mango scale is the most important limiting factor for mango production and most of the mango grower farmers didn't know the insect pest infecting their mango and only few farmers nearby Green focus knew the insect pest with less than 10 years experience. External support provided to control the pests was only training by Agricultural Office at FTC and few farmers with their indigenous knowledge started practicing cultural control methods like pruning, smoking and site clearing of the heavily infected parts of the mango trees .Observations from the survey indicated that the pest causes premature drop of leaves, dieback of twigs and branches, stunting and distortion of fruits, drop of unripe fruit and the fruit attacked by this insect pest become less marketable because of low quality.

The current trend of dispersal of white mango scale across the Uke kebeles needs a strong desire for planning and implementing control measures. The dispersal rate of the pest is rapid indicating that the pest can easily invade the whole Uke kebele and due attention should be given especially by owners cultivating mango as the private agencies and the support should be given for mango grower farmers on management practices of the pest. In general doing with collaboration it is easy to manage the pest and earn the better income and sustains the life of the mango grower farmers.

5.1.2 Recommendations

- White mango scale has been introduced to East Wollega with entry of Green focus ltd with the foundation of this private company. Therefore, additional study should be conducted for how to decrease the pests from inhabiting this essential crop plants.
- White mango scale was found spreading very fast in Uke kebele and mechanisms of its dispersal have not been yet known, implementation of sanitary measures may be unfounded, it is recommended that mango growing farmers in the kebele should be trained to prevent their mangos from white mango scale infestation as much as possible, and remove any infested part before the occurrence of heavy infestation that would be difficult to take the control measures.
- Taking the current distribution of white mango scale in Uke in to consideration, its district and Zonal–wide distribution should be surveyed.
- Biologically important predator beetle, *Cybocephalus binotatus, Chilocorus sp.* and parasitoids *Cales noaki* (parasitic wasps) should be multiplied in the laboratory and released to the field to reduce the number of whit mango scale.
- Cultural practices such as pruning, smoking and consistent scouting for white mango scale removing the heavily infected parts of the mango trees are essential management practices that should be encouraged in Uke kebele for every harvest season.
- It was known that some improved mango varieties were less susceptible to white mango scale infestation and the seedlings of such mango varieties should looked for studied systematically and provided for the mango grower farmers
- If Insecticides were available ,the best period of application for control of white mango scale is from January to May when the population peaks of the pest build up on the onset of Autumn
- Integrated Pest Management should be implemented for the control of the white mango scale.

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Questionnaire

This questionnaire has been prepared to gather information from mango farmers of Uke kebele regarding their knowledge about white mango scale, its impact on their production of mango and management practice they undertake.

I would like to thank in advance for your kind cooperation.

I Demographic data

1 Sex: A Male B Female

2 ***Age***: A below 25 years___B 26-35years___ C 36-40 years D 41-56 years___ E 57-61years __ F above 62years_____

3 ***Marital status***: A Married ____ B Unmarried _____

4 ***Level of Education***

A Never attended School____ B attended primary School____ C attended High School_____ D Completed High School _____

II Information about white mango scale and its current status and its impact on mango.

1 For how long have you been producing mango?

A below 10 years B 10-20 years C 21-30 years D above 31 years

2 What kind of mango varieties are you cultivating currently?

_____

3 Did you experience on your mango farm the insect pest infecting mango before?

A yes B no

4 How many years old that you noticed that your mango get infected and show different symptoms?

A 10 years B 20 years C 30 years D above 35 years

5 What damage do the white mango scale caused to your mango?_____

6 Did the damage with the insect pest increase or decrease your annual income?

A increases B decreases C no change

7 If it affect your income in what aspect?_____

8 What methods did you practices to control the infestation?

A cultural B chemical C both D others _____

9 If you used cultural method to manage the pest what are the major onces?_____

10 Did the method you used to manage the pest is efficient to control the pest?

A yes B no C to some extent

11 Which parts of the plants were first attached by the pest?

A leaves B fruits C branches D others_____

12 How do you describe the effect of the pest on the infected mango trees, right starting from its symptom on mango trees and its subsequent manifestation?

_____

13 Did you have observation whether the pest was affected the local and the newly emerged varieties of the mangoes equally?

A yes B no C If no why_____

14 Have you ever seen such kind of pest or diseases affecting the mango trees in such magnitude in your life in this area?

A yes B no

15 Have you ever received any external supports from Government, NGOs and other agencies?

A yes B no

16 If yes what were the type of support and the result obtained?_____

17 Did you have any observation as to whether the newly distributed improved mango seedlings distributed to them by the project infected or not?

A yes infected B no not infected

18 Have you seen any chance of survival on the new mango seedlings planted on their farms?

A yes B no

19 What protection measures did you take for the new mango seedlings not to be affected by the pests_____

20 Currently, what is the status of the infestation?

A very high B high C moderate D low

An interview

Guiding questions related to effect of the pest on the mango grower farmers

1 Can you please tell me the extent of average mango production collected from a tree in this year?

2 Can you please tell me the extent of average household production of mango and the corresponding income earned from sales of mango during the last cropping year?

3 Can you please explain how the pest has recently affected your households' economy (impact on food security, schooling children, agricultural crop productivity?