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Study on prevalence of white mango scale and their Management options in Alge Sachi district of Illu Aba Bora zone, Oromia regional state, Ethiopia

By

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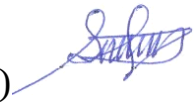
Advisor Sisay Dugassa (PhD, Medical Entomology) 

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This is to certify that the thesis prepared by Tsegaye Ayana, entitled **"**prevalence of white mango scale and their management options at Wayoseko kebele," Presented in the fulfillment of M.sc in Biology.

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Acronyms /Abbreviations

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

Summary

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 It spread and has become a threat to mango production in almost all Oromia zones of the districs and the kebeles and affected economic benefits of mango farmers. The objectives of this study was to assess the status and prevalence of white mango scales infestation, distribution and the existing capacities to control the pest at Wayoseko kebele of AlgeSachi district of Illuababora zone of Oromia Regional State. From the current study, white mango scale was the crucial mango production limiting factor in Illuababora zone of AlgeSachi District because of its high rate of dispersal in all mango plantations in the vicinity. The data were collected randomly from January 10/5/2011 to June 10/10/2011 from the orchard of Green focus through observation, interview and Questionnaire which distributed for purposefully 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 farmer's indigenous knowledge of pest management practice.

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

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CHAPTER ONE

1. INTRODUCTION

1.1Background of the study

Tropical and Subtropical fruits can 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 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 (Ofgaa Djirata *et al*, 2017).It also used as animal feeds and known to play a vital role in export and import business and hence generates foreign currency 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 Honja, 2014).Mango (Mangifera indica) is a fleshy stone fruit belong to family Anacardiacae and tropical fruiting trees in the flowering plants. Mango is cultivated in more than 85 countries in the world and is one of the widely and globally traded tropical and subtropical fruit trees in the world (Takele Honja and Temesgen Fita, 2014).The total amount of mango production in the world was around 35 million tons by the year 2009 (FAO, 2009).Mango in Ethiopia cultivated in different regions and it is proceeded by citrus and banana and 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 green housegase missions, particularly,temperature,rainfall and relative humidity (Nether and Schoof,2010).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 (Giant –Reto,et al,2002,Hoegh-Guldberget,*et al*,2008,Nether Schopf,2010) These situation is supported by the presence of natural enemies of the pests in new area of distribution resulting in increase in abundance of acquit ion of new host and pathogen transmission (Tesfaye Hailu *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 without little or no concern for the insect pests disease and pests were transported along them. Due to imports of mangoes with tropical and subtropical 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 Hailu *et al*, 2014).Mango in Ethiopia is 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 by Upper Awash Agro Industry Entreprise (UAAIE).These varieties are distributed to different parts of Ethiopia by (UAAIE).In2001/2002 a private farm called Green Focus limited 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 Regional Western Ethiopia (Temesgen Fita, 2014).Many farmers grow mango for the source of food ,income and shading purpose. Mango in considered as an important element in a certain sociological aspects 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 and weather conditions.

Mango suffers from several diseases at all stages of its development .All parts of the plants: trunk, branches, leaves, petiole, flower and fruit are attached by insect pests. Among the insect pests infecting the mango, white mango scales are the devastating insect pests. White mango scale, Aulacaspis tubercularis is one of the agriculturally important insect pest belong to order Hemiptera and characterized by having a piercing and sucking mouth parts hence it injures mango tree by feeding on the plant sap through leaves ,branches and fruits. Recently it become a serious on mango in all mango orchard in many countries (Tsegaye Babege et al,2017).These insect pest affect the production and expansion of mango in Ethiopia .Post harvest physiology and storage of tropical and subtropical fruits are very important(S.K.Mitra and E.A.Baldwin,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 (mature green)(Mitra ,et al,2005).Mitra (2005) states that mango tree are subjected to chilling injury when stored below 10 c^0 and the system

which may not develop until the fruit is returned to high temperature. The production of mango is constrained by the insect pest and the quality and productivity become decreased. Mango fruit pests include fruit flies, fruit borer ,stone weevil and sucking moth (Mitra ,et al,2005).These new pest infecting mango trees was *reported in an orchad* of Indian company, Green Focus Ethiopia western Ethiopia (Ofgaa Djirata,Emana Getu and Ruth Kahuthia-Gathu,2017).Plan International Ethiopia-Oromia Programme Aera 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 Hailu,*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 by promoting improvements in 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 Hailu, *et al* 22014).The overall generation of white mango scale is from 35-40 in females and 23-28 days in males (Ofgaa Djirata *et al*, 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 spread of the insect 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 research was prepared to investigate the prevalence of mango fruit pests and their management options at Wayoseko kebele of AlgeSachi district of Ilubabora 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 of the study

1.3.1 General objectives

To assess the status of white mango scale infestation, distribution and the existing capacities to control the pest.

1.3.2 Specific objectives:

To determine prevalence of white mango scale infestation in AlgeSachi district.

To assess the effect of white mango scale on the income of the mango cultivating farmers of the district.

To identify management options of white mango scale that farmer's use in the area.

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CHAPTER TWO

2 Literature Review

2.1 General overview

Tropical and Subtropical fruits can 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 (Takele Honja, 2014, Amee Revani (2013) state that mango is the king among tropical and subtropical fruits and is greatly relished for its succulence, exotic flavor and delicious taste in most countries in the world. Mango (Mangifera indica) is a tropical and subtropical evergreen tree native to Indian subcontinent more likely in Burma-Malaysia region. Following India in volume of production, China 3673, Thailand 1800, Mexico 1679, Pakistan 1674, Indonesia1478, Brazil 1000 and Philippines 985 and all are in metric tons and Nigeria is the first in Africa and Egypt is the second in mango production (Tesfaye Hailu et al 2014).The world production of mango is estimated over 45.22 million tons, with a production area of 5.64 million hectares (Tsegaye Babege *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 Djirata,2017).Mango has become naturalized and adapted throughout tropics and subtropics in conjunction with the spread of human populations and its tolerance to a wide range of climatic conditions. Mango tree is successfully cultivated under a conditions of very hot and humid to cool and dry area and mean annual rainfall between 400mm to 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 (Ofgaa Djirata 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. Marketing fresh and processed products generates income which can act as an economic buffer and seasonal safety net for poor households and diversification in to fruit production can generates 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. It is preferred for its high pleasant aroma and taste and high nutritional value.

The mango crop is also cultivated in Ethiopia and Southwest Ethiopia and it is the frist crop grown (Tesfaye Hailu,*et al*,2014).The area of mango production in different regions of Ethiopia is

about 3789.47 ha in Oromia,3375.89ha in SNNPR,652.56 ha 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 (CSA,2012/2013).

The trees in Ethiopia is developed from seedlings and are 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 by the Upper Awash Agro Industry Entreprise (UAAIE).These varieties are distributed to different parts of Ethiopia by (UAAIE).In 2001/2002 a private farm called Green Focus limited 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 Regionof Western Ethiopia (Temesgen Fita,2014).Many farmers grow mango for the source of food ,income and shading purpose.Mango is considered as an important element in a certain sociological aspects 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 and weather conditions.

2.1.1 Mango production in Ethiopia

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. The national research system has developed a number of varieties built is not widely spread. Experiences from other countries in growing this crop will therefore contribute to the success and widespread of fruit (Takele Honja,2014).Mango is traditionally grown in Ethiopia primarily 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 Unit Arab Emirates (Ofgaa Djirata, 2017). Upper Awash Agro Industry Enterprise (UAAIE) and Raj Agro PLC are among modern farms producing fruit at a relatively larger scale. Very limited number of companies is producind fruit juices in Ethiopia of which a mango juice producing company is found in Sebeta 24 km Southwest of Finfinne/Addis Ababa (Ofgaa Djirata, 2017). The export

share of mango from Ethiopia was reported to have been very small due to low productivity and quality.

2.1. 2 Distributions of White Mango Scales (*Aulacaspis tubercularis*)

The white mango scale *Aulacaspis tubercularis* are distributed in a wide range of climates (Temesgen 2014) and now widely spread in mango growing countries (egyptian academic@yahoo.com) .It is a tropical species originated in Asia and White mango scale has been firstly reported in India as Tesfaye Hailu et al (2014) cited in his thesis.It has been spread by the transport of infested plant material and now widespread in many mango growing countries including the USA (Florida),Northern part of South America (Brazil, Jamaica and Colombia) and East and the West Coasts of Africa (Egypt, Ghana and Kenya) and white mango scale was introduced into Florida and Australia with the importation of mango fruit from India (Abo-Shanab 2012 cited from Brochsenius,1996).The detection of white mango scale on mango was on Pacikstan mangoes on arrival in the United Kingdom Temesgen(2014) 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 most of the tropical pacific Islands and international Institute of Entomology and it become 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 in Egypt (Egyptian academic @ hayoo.com).The mango scale is the first recorded incidence of mango (*Aulacaspis tubercularis*) in South Africa(Tesfaye Hailu *et al*,2014).In Ethiopia ,white mango scale was recorded as Aulacaspis tubercularis in Ambo Plant Protection Research Center with the aid of binocular microscope from internet and the sample was sent to America in January 2011for further confirmation the Ministry of Agriculture.I ts common name is white mango scale,Hemiptera :Diaspididae,Aulacaspis tubercularis and it was first recorded in Ethiopia. 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 the infestation has spread five woreda producing mango namely:Gida Ayana ,Sasiga , Sibu sire ,Limu and Diga and more than 33% of the mango producing area are infected by white mango scale (Temesgen and Tesfaye *et al*,2014). From the above point's one can judge that the insect pest invaded the East wollega and spread to mango producing district from the mango which is planted at different Oromia zones, districts and kebele farm land occupied by Green Focus. This study was aimed that to assess the

prevalence of mango fruit pests current at Wayoseko kebele of AlgeSachi district of IlluAbaBora zone of Oromia regional State.

2.1.3 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 vigor 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 2.6)(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 mangoes and among insect pests inflicting damage to mango.



Plate 2.1 Change in color and wilted of mango leaves by white mango scales at Wayoseko kebele.

2.1.4 The Current Status of the pests

White mango scale, Aulacaspis tubercularis Newstead (Hemiptera :Diaspididae) is currently a wide spread pest throughout all mango producing areas in South Africa (Labuschage,VanHaburg and Froneman,1995 cited from De,Villiers 1984).Although the mango scale doesnot cause internal fruit damage its cosmetic effect on the fruit skin results in a significant decrease in ratio of exportable fruit and substantial financial losses for the mango growers (Labuschage, Van Haburg and Froneman,1995).The researchers and expertise team reported from Federal Ministry of Agriculture and National Research Center were identified the insect pest attacking mango crop and also reported it as a white mango scale They also confirmed that the pest is new for the

locality and for the country as the whole (Temesgen Fita,2014).The new pest causing damage to mango trees was reported in 2010 in an orchard of the Indian Company Green Focus Ethiopia in Western Ethiopia (Temesgen Fita,2014).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 the site of the first record within one year (Ofgaa,Emana and Ruth,2017).The pest has been transported most likely with fruits.As Temesgen (2014) cited from Timothy (2006) 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. Based on this idea it is suspected that the scale was distributed from its initial infestation area Green Focus Ethiopia (Alphonson mango orchard) mango varieties to all mango growing neighbor districts of the zone like Gida Ayana ,Sasiga ,Sibu sire,Limu ,Diga and Gobu sayo. Even though, the first emergence of the scale was recorded at Loko Administrative kebele in Guto Gida, it covered wide geographical area within one year due to its flight capacities which contributes its distribution in any direction (Temesgen Fita, Tesfaye Hailu *et al*, 2014)

2.1.5 Management Practice of White Mango Scale

Like other phytophagous insects, white mango scale needs its host for food, oviposition site and shelter. In the process of exploiting the host plant for the aforementioned purposes, 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. The outbreak for insect pest plague or disease spread more and more often become a major concern of the forester the farmers of the public health custodian (A.K.Vyas, 2008).For these 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 (A.K.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 (A.K.Vyas, 2008).The preparation of crop time tables provides a solid foundation for analysis of pest damage and cost benefits ratio in pest management. Because, if insect pests of Agricultures are not checked it would be difficult to grow

crops at (John.Doyen, Paul R Enrich, 1978).Accordingly, application of pest management in the field is essential to know the way how to manage pests (A.K.Vyas, 2008).

2.1.6 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.

2.1.7 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.

2.1.8Chemical 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).The use of chemicals or pesticides may give faster solution Temesgen (2014) states that Green Focus Ethiopia owing farm land at Loko Administrative kebele use chemical insecticides; Organophosphates to destroy insect pest. The way of using the chemicals to the mango to attack the pest is by spray mechanism. The spray mechanism undertaken twice a year before the setting of the flower and after harvest and due to ecological area of the farm i.e. lowland with an altitude of 1348 m and temperature of 26-34°c the spraying is carried out daytime and the spray is practiced by daily workers.

2.1.9 The implications of the pest to mango value

The major sources of inputs production of mango in Ethiopia are farmers, agricultural office and markets. In general, the sources of inputs for mango production in Ethiopia are agricultural offices markets, agricultural institutes and own stock. (Takele,2014).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 Ethiopia 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 fruitand vegetables and Horticulture inits program to support business organization and their access to marketing (Takele, 2014).In the same way, the emergence of the pest has become a stumbling block to realize the objectives of mango value at IlluAbaBora zone of mango growing districts and hence it reduces the market opportunities, qualities and productivities of the owners of the mango of the farmers cultivating mango. This is because of the fact that sustainable utilization of 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 and increase the quality and productivity of mango for marketing, the impacts of the was must be handled at all areas of mango cultivations unless the infestation of the mango with no doubt decreases the marketing of mango and hence, income obtained gets decreased.

CHAPTER THREE

3 Materials and Methods

3.1 Description of the study areas

This study would conducted at Wayoseko kebele of AlgeSachi district of IlluAbaBora zone ,Oromia Regional State , 654 km west of Addis Ababa and at a distance of 54km from the capital city of Mettu town .The district is located at longitudes between 33^0 $17^{''}$ E and 35^0 $57^{''}$ E and latitude 8^0 $23^{''}$ N and 8^0 $44^{'}$ 37" N with a total land area of about 80,587 hectares and an elevation range of 1300 -2300 m.a.s.l; the lowest altitude is found at Gaba River and the highest is on the Sachi area. The district is bordered with Mako District in the east, Bilo Nopha, District in the south, Siba Jorgo in the North, Darimu district in the west and Nole Kaba District in the North West direction. It has thirty three kebeles (the smallest community based administrative units in Ethiopia) among which three is the urban kebele. The administrative town of Alge Sachi District is the urban kebele. WayoSeko kebele is located at 8° 30′ 00″N and 35°39$^{'}$ 0″E IlluAbBora zone with the total land area of 2462.3 ha (Figure3.1). The study was conducted on mango orchard of Green Focus. The mango farm land size was 20 hectares. The mango orchard of Green Focus was planted (5-35) years ago (old Varity). The mangos were from (8 -10) m tall and spread according to farmer's settlement in the kebele, that means not found in the same intervals. Wayoseko (Fig.3.1) received a mean annual rainfall of 1650mm.Coordinates of the study area were recorded using GPS and Map of the study area was plotted Using GIS soft ware.Mango farms were according to the settlement of the farmers(not at series of spots) within intervals (distances)of 5km to 30km land distance would considered for sampling purpose.

3.2.1 Climate

The districts have hot and humid climatic condition. The minimum and the maximum annual rain fall and temperature ranges from 1200-2200mm and 15-25^0 c respectively (ADRADO, 2010).

3.2.2 Population

According to Population projection (2010), the total population of the District is about 106,953 of which 51122 (47.80%) are males and 55831(52.20%) are females. Of the total population, 18,965(21.17%) males and 70,612 females (78.83%) live in *urban* areas while the rest 87,988(44759 males and 43229 females) (82.25%) live in *rural* areas

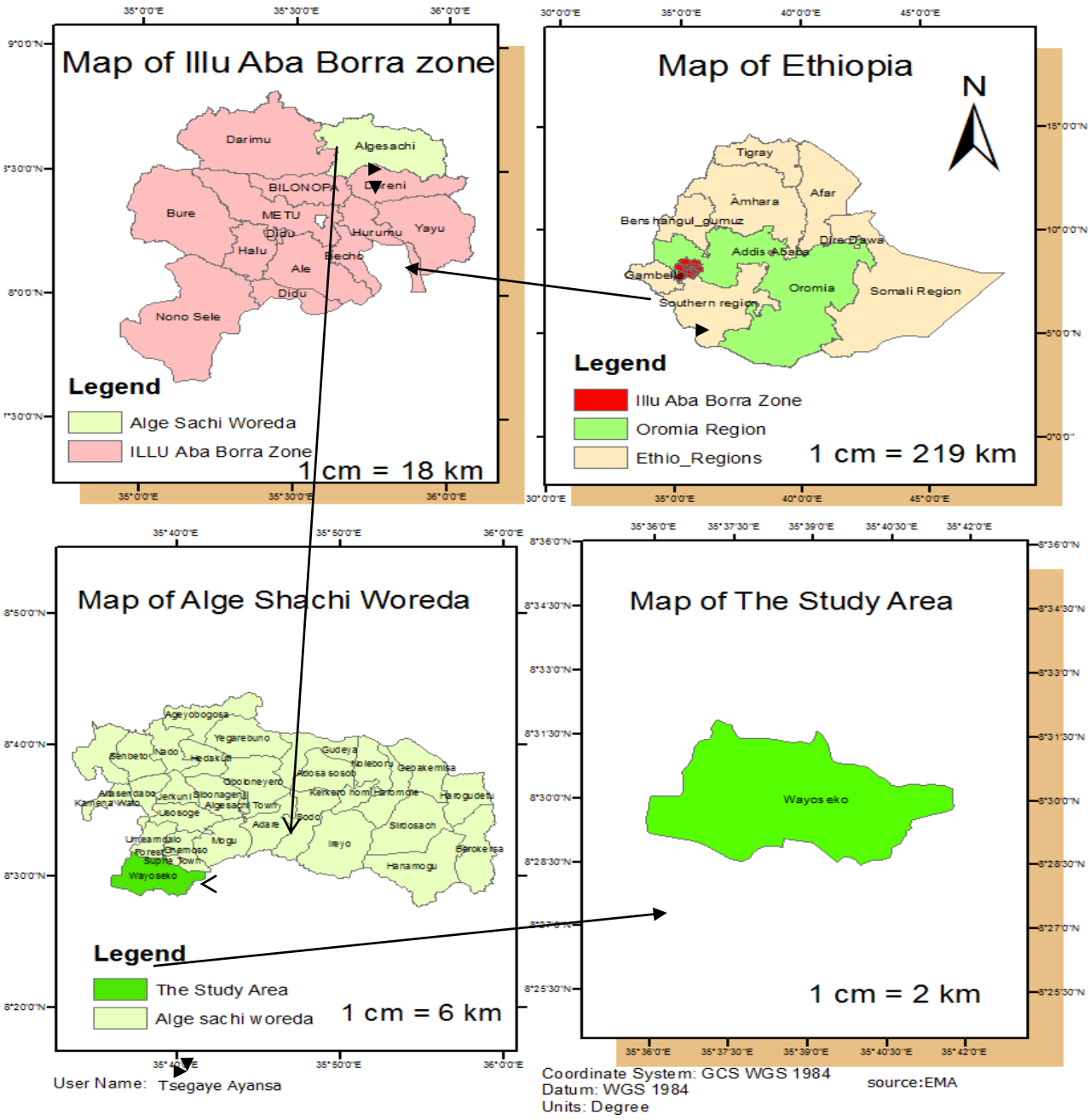

Figure 3.1 Map of Algesachi District and Wayoseko kebele

3.3 Method of Data Collection and Sampling Procedures

Survey on the prevalence of white mango scale on mango trees were collected from the Office of Agriculture of AlgeSachi district of IluAbaBora Zone. A data sheet to recorded the presence or absence of the pest incidence and pest density would prepared .When the presence of the pest would confirmed, leaf infestation level would determined by hand lens and visual estimation of proportion of leaf infested by taking five mango trees per five leaves per five branches randomly

from each kebele. Then the estimation would make on the whole tree basis as well as on the lower branches of on the tree only because of variation in within tree distribution of the pest. In infested fields ,the pests density would determined by counting colonies on the upper and lower sides of five leaves randomly picked with eye closed from the lower branches of up five randomly picked from depending on tree availability. The mango farm plantations were occurred according to the farmers settlement (not at a series of spots) within the intervals of 5km to 30km distance would considered for sampling purpose from its first origin of infestation. The data would collected randomly from January 10/5/2011to June 10/10/2011 from the mango farm lands and Questionnaire would distributed for purposively sampled population. The Questionnaire would prepared for 70 participants, observation, and an interview would made for 10 participants. The area name and GPS readings of the mango survey would presented in the form of the table and graph.

3.3.1 Data collection tools

Questionnaire and Interview

Questionnaire was employed to collect quantitative and qualitative data from selected farmers. The questionnaire was prepared for respondents farmers. Mango production in Wayoseko kebele was annual. It occurs once in a year and the peak harvest is in March to June and hence, the data would 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, prevalence and management practices options of the farmers in the past and present situation of the pests were collected from sampled mango grower farmers and an interview would made for the Head and dispute of Agriculture Office of the district.

3.3.2 Data Analysis

Data were analyzed and interpreted by qualitative (descriptive method) and quantitative (percentage, frequency, tabulation) and methods using Microsoft office excel 2010 software. Calculation of the percentages and frequency of counts were used to arrive at a general conclusion and used as a tool for analysis of quantitative data. In general, close-ended questions were analyzed through tables (frequency) and percentages to compare results. Open-ended questions including interview and observations were analyzed using descriptive methods.

CHAPTER FOUR

4. Result and Discussions

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

4.2 Demographic Characteristics of the respondents

From the total number of participants considered for questionnaires, the response rate obtained was 100 %(n=70). From the total respondents 92.86% were males and 7.14% females, most of the participants were married (Table, 4.1)

Table 4.1 Sex ratio of the respondents

Sex	Frequency	% response
Male	65	92.86
Female	5	7.14
Total	70	100

Age structure of the respondents showed that about 40(57.14%) were between 36-45 years old, 14(20%) were between 26-35 years old and 10(14.29%) were between 46-55 years old, 5(7.14%) were below 25 years old, 1(1.43%) were between 57-61 years old and 68(97.1%) and most of the respondents were married (Table 4.2)

Family size of the respondents' household greatly varied, i.e. those having 2 members were 2(2.86 %), 3-6 members 54 (77.14%), 7-10 members 8 (11.43%) and above 10 members were 6 (8.57 %).

Table 4.2 Age structure and marital status of the respondents in Wayoseko administrative kebele

Age group in years							Marital status		Total
	<25 years	26-35 years	36-45 years	46-55 years	56-66 years	Above66 years	Married	unmarried	
No respondents	5	14	40	10	1	_	68	2	70
%response	7.14	20	57.14	14.29	_	_	*97.1*	2.9	100

Information obtained from the respondents demonstrated that 49 (70%) of the participants have attended basic education, of which 10 (14.29%) have attended 2^{nry}school and 5 (7.14%) have completed high school 6 (8.57%) have never attended school (Table, 4.3)

Table 4.3 Education background of the respondents in Wayoseko kebele

Variables	Frequency	%response
Never attended school	6	8.57
Attended primary school	49	70
Attended 2^{nry} school	10	14.29
Completed high school	5	7.14
Total	70	100

4.3 Mango production and farmers experience about white mango scale in Wayoseko kebele Information gained from the participants showed that mango production is a common farming practice in Wayoseko kebele and from the respondents 45 (64.29%) of them was informed that they have practiced in mango production for 10-20 years ,where 15 (21.43%) of them have an experience of mango production for about 21-30 years and 6 (8.57%) and 4 (5.71%) of them have an experience of mango production in less than 10 and greater than 31 years respectively (Table,4.4).The respondents was replied in open-ended questions what kind of mango they 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	6	8.57
10-20	45	64.29
21-30	15	21.43
Greater than 31	4	5.71
Total	70	100

About 56 (80%) of the total respondents didn't know the insect pest and only14 (20%) of them knew the insect pest infecting their mango. Those who knew the insect pest 6 (8.57%) of them said that their experience where less than 10 years and 8 (11.43%) 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

Variable	Frequency	Percentage
Yes	14	20
No	56	80
Total	70	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 40 (57.14%) of them said that the leaf part of the plant was infected first and the infestation slightly go to the branches and the fruits 17 (24.29%) and 13 (18.57%) respectively as in (Table 4.6) below. White mango scale causes fatal damage to late maturing and ripening stage of the fruit may 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.

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

Valid	Frequency	Percentage
Leaves	40	57.14
Branch	17	24.29
Fruits	13	18.57
Total	70	100

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 at Alge market which is reduced in quality and below export requirement.



Figure.4.1 Infected Mango fruits on sale in Alge town market

Of the respondents48 (68.57%) of them said that currently the status of the infestation was very high and14 (20%) and 8(11.43%) 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).

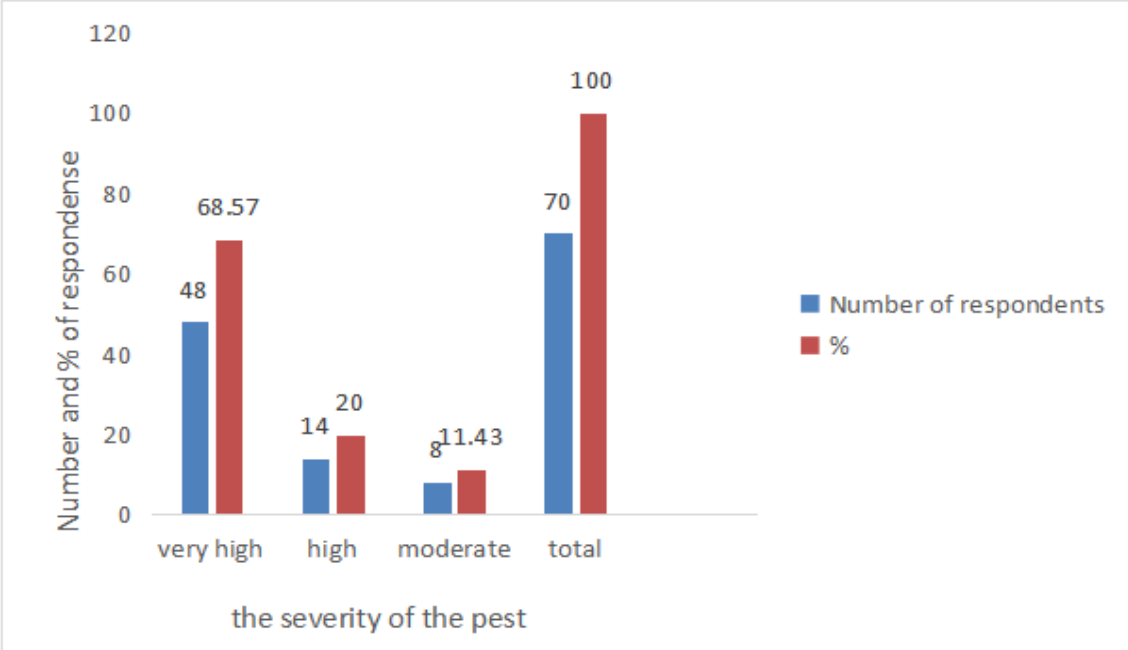

Figure 4.2 Graph showing the current status of the pests

4.4 Management practices of white mango scales in Wayoseko kebele

From the total number of the respondents, about 60(85.71%)of them attempted to control the white mango scale used cultural, 7(10%) used chemical methods and 3(4.29%) preferred to used both cultural and chemical methods no one preferred to use other methods as shown (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). 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).

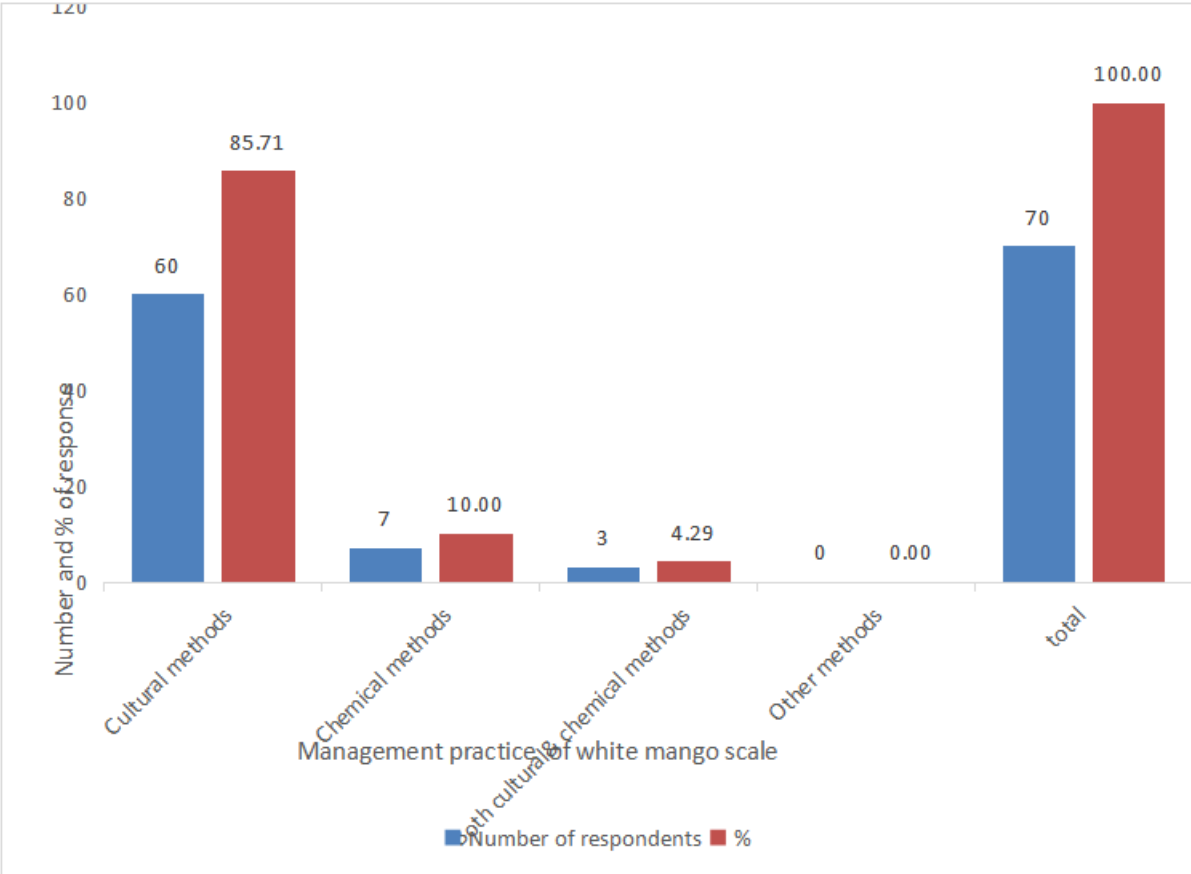

Figure4.3 Graph showing management practices of white mango scales

From the total population, 57.14% of the respondents said that the method employed to control the pests was not efficient where as 22.85% mentioned that the method used was efficient to some extent to control the pest and 20% 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 FTC) by trainee.

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

Valid	Frequency	Percentage
Yes	14	20
No	40	57.14
To some extent	16	22.86
Total	70	100

The white mango scale is distributed in a wide range of climates (Temesgen, 2014) and now widely spread in mango grower 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 Wayo kebele, the locus of first seen to all mango growing neighbor kebeles of the districts like Wayoseko Chemoso, Mogu, Umeamdalo, ususige, Aliasendabo, Jarkuni, Adare, Sodo, kamewato, and nearby districts like BiloNopa and Darimu in five directions. An interview were also made for AlgeSachi District Agriculture Heads Ato Tsegaye Teferi and Deputy's Ato Fikadu Etana (Figure 4.4) on the distributions and spread severity status, prevalence and management options provided for the farmers on white mango scales and responded that at the woreda 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, pruning after harvesting, and removing all the leaves etc.



Figure 4.4 an Interview made at AlgeSachi 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, Wayo kebele white mango scale has distributed to mango growing of the kebeles and districts. Data obtained from field survey (Table, 4.8) showed that the maximum air distance covered by white mango scale was 30km to the North-East of Wayoseko, Sodo, from its first origin of infestation in the district‘s kebele 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 part of IlluAbaBora Zone. The dispersal rate is alarming indicated that within a short period of time the pests can invade the whole mango growing areas of the Illu Aba Bora Zone particularly Alge Sachi 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	Distribution air distance in km.
Wayo kebele	AlgeSachi	South-East	AlgeSachi	Wayoseko	5
Wayo kebele	AlgeSachi	North	AlgeSachi	Chomoso	6
Wayo kebele	AlgeSachi	North- East	AlgeSachi	Umeamdalo	7
Wayo kebele	AlgeSachi	North- East	AlgeSachi	Mogu	15
Wayo kebele	AlgeSach	North	AlgeSachi	Usosige	20
Wayo kebele	AlgeSachi	North-West	AlgeSachi	Aliasendabo	18
Wayo kebele	AlgeSachi	North-East	AlgeSachi	Sodo	30
Wayo kebele	AlgeSachi	North-East	AlgeSachi	Adare	23
Wayo kebele	AlgeSachi	South-West	BiloNopa	Sulibosoka	24
Wayo kebele	AlgeSachi	North-West	Darimu	Boto	26

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

Severity status of white mango scale in mango farm land was studied in Wayoseko kebele by taking samples from its original infestation across district and kebeles. To indicate the severity status and prevalence of white mango scale, even though the leaves, small shoot, branches 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 Wayoseko and Chemoso kebele with a mean average of 24.8 and 24 clusters per leaf with air distance of 5km and 6km from the first Loci of the pests, Wayo kebele mango farm land respectively. Two high peaks occurred in Boto and Sodo at air distance of 26km and 30 km with a mean average of 12 and 9.6 clusters per leaf respectively. AS the distance between mango farm land increased from the first loci to the second to the tenth with a mean averages of clusters per leaf with air distance;-

Wayosek and Chemoso, Chemoso and Umeamndalo, Umeamndalo and Mogu, Mogu and Aliasendabo, Aliasendabo and Usosige, Usosige and Adare, Adare and Sulibbosoka ,Sulibosoka and Boto, Boto and Sodo;-24.8 and 24, 24 and 23, 23 and 22, 22 and 20.4, 20.4 and 18.8, 18.8 and 16, 16 and 14.2, 14.2 and 12,12 and 9.6 ;- 5km , 6km ,7km ,15km ,18km, 20km, 23km, 24km,26km ,30km as 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.

4.7 Distribution and Severity Comparison between sampled district and kebeles

As white mango scale emerged in AlgeSachi district ,Wayoseko 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 Conclusion and Recommendations

5.1Conclusion

Mango is one of the most important income-generating fruit tree in the rural communities and its production in Wayoseko is annual with the peak harvest in March to June and mango producers use as food by themselves, 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. Now a day's Mango production in Wayoseko kebele is decreased by white mango scale in District .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 was concluded that the rate at which white mango scale has spread in all mango growing kebeles is a reminder that the prevalence of this insect pest has become beyond internal, although it is a very new insect pest in the Wayoseko 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 wayoseko kebele 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 Wayoseko kebele and due attention should be given especially by cultivating mango as the private indivduals 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.

5.2Recommendations

- White mango scale has been introduced to IlluAbaBora Zone of AlgeSach district's of wayoseko kebele through air from infested mango with white mango scale. 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 Wayoseko 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 and prevalence of white mango scale in Wayoseko kebele in to consideration, its district and Zonal–wide distribution should be surveyed.

- 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 Wayoseko 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

- Integrated Pest Management should be implemented for the control of the white mango scale.

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Appendices

Questionnaire

This questionnaire has been prepared to gather information from mango farmers of Wayoseko kebele regarding their knowledge about the prevalence of mango fruit pests (white mango scale), its impact on their production of mango and their management options 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. 36-45 years D. 46-55 years_ E. 56-65years F .above 66 years_____

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 (mango fruit pests) 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 aspects?

_____

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 types 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 prevalence 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 farmer

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

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?

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