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Trend in Mango Production and Potential Threat from Emerging White Mango Scale, Aulacaspis tubercularis (Homoptera: Diaspididae) in Central and Eastern Kenya

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Abstract
White mango scale, *Aulacaspis tubercularis* Newstead was reported to have been recorded in Kenya long ago. However, there has been no documented report of study regarding its impact on mango production in this country. The current study surveyed the distribution, severity status, farmer's knowledge and management practices of *A. tubercularis* in three counties in central and eastern Kenya in 2015. It was found that the pest was distributed in almost all of the 75 orchards addressed in the counties. The mean and standard deviation of female *A. tubercularis* on mango leaf was 1.35±.81 in Kiambu, 2.75±3.17 in Machakos and 1.47±1.49 in Murang'a County, indicating irregular distribution among orchards of each county, mainly among that of Machakos and Murang'a. The severity status was found to have been more of mild with few high and very high statuses. About 66.67% of mango growers knew the presence of the insect of which 14% did not consider it as pest. About 57.33% of the respondents attempted to control white mango scale by the use of pesticides and other methods, of which 13.95% said, could control it as planned. Further systematic study is needed to implement informed management system to control this emerging mango pest.
Keywords: White Mango scale, severity, control, fruit

Introduction

Mango, *Mangifera indica* L, is believed to have been originated in tropical Asia, and distributed to all tropical and subtropical regions, indicating its conjunction with the history of the spread of human being (Balock and Kozuma, 1963; Dirou, 2004). Its current distribution covers more than 80 countries in which mangoes are grown for commercial purpose (Bhushan, 2013).

Mango is widely consumed as a fresh fruit and various forms of preparations. It is known for its high content of sugar, protein, fats, salts and all known vitamin (Nabil *et al.,* 2012). It is also used as animal feeds, poultry diets, in Ethnopharmacology and various chemical industries in different parts of the world (Wauthoz *et al*., 2007; Kayode and Sani, 2008; Nwinuka *et al.,* 2008). Mango is known to play vital role in export-import business and thence generates foreign currency (www.unctad.org).

Pertaining to its enabling agro ecological climate, Kenya is known to be one of the leading mango producers in East Africa, where the production is both at large and small scale levels for export, processing into juice and fruit concentrates, and for domestic consumption (Boersma, 2006; HCDA, 2008). It is stated that Kenya could manage to take the advantage of being situated on both the Northern and Southern Hemispheres and as a result enjoys two seasons of mango production (AMAGRO, 2011). Accordingly, the average of mango produced for the years 2005-2007 was known to be 16,520 hectares of land cover and 295,802 metric tonnes of fruit harvest (HCDA, 2008). The main mango producing regions being in the eastern, central and coast areas, most of the counties in Kenya produce mangoes (www.jkuatenterprises.com).

Mango is known to encompass about 1000 named varieties worldwide. In Kenya, both indigenous and exotic varieties are grown. It was reported that 50 mango cultivars were grown in central and eastern Kenya (http//:www.worldagroforestry.org) of which Griesbach (2003) described 31 cultivars in detail. Okoth *et al*., (2013) also states the presence of several exotic and indigenous mango varieties in Kenya. The exotic varieties are known to be of higher quality compared to the local ones and their production targets export market. Kenya exports mango to various international markets. According to AMAGRO (2011), it exported approximately 2,500 to 3,000 tons of mango fruit to its second export market, Tanzania in the year 2009.

Mango production in Kenya is reportedly constrained by various insect pests and diseases (www.biovision.ch; www.jkuatenterprises.com; Findlay, 2003; Griesbach, 2003). These include pests such as mango fruit fly, mango seed weevil, mites, thrips and mealy bugs, among others. Powdery mildew and anthracnose are among the diseases that affect mango production in Kenya.

It was long ago since Kenya was mentioned among the African countries from where white mango scale, *Aulacaspis tubercularis* Newstead was identified (www.freshfromflorida.com). Even though the presence of white mango scale in Kenya is not denied, it is not considered as an important pest (personal communication with Dr. Njuguna from Kenyan Agricultural and Livestock Research Organization, Kandara branch, on October 08 2014). White mango scale is a hard scale insect which is reported to have damaged mango in various mango

growing countries (Cunningham, 1996; SRA, 2006; Germain *et al*., 2010; Abo-Shanab, 2012). Its population density was formerly recorded on mangoes in few parts of the world. However, it has been spread by the transport of infested plant materials and widened its scope and has become an important mango pest in many mango growing countries including West Africa, Egypt, South Africa, North and South America and the Caribbean Islands (El-Metwally *et al.,* 2011; Nabil *et al.,* 2012). It is stated that white mango scale is currently posing a devastating impact on mango plantation in western Ethiopia (Temesgen, 2014; Ofgaa and Emana, 2015). The reports indicate that the pest was introduced in to the country around 2010 and is spreading since then with an alarming speed in the west direction, the region known for its high production of mango. This pest attacks leaves, fruits, and twigs and causes serious damage to the plant (Figure 1). Its infestation causes dieback, yellowing of leaves and development of conspicuous pink blemish on mature and ripe mango fruits, a damage which may result in market resistance of the fruit. Both pesticides and biological control methods were applied to control the pest, where some could show good results (Labuschagne *et al*., 1995; Abo-Shanab, 2012).

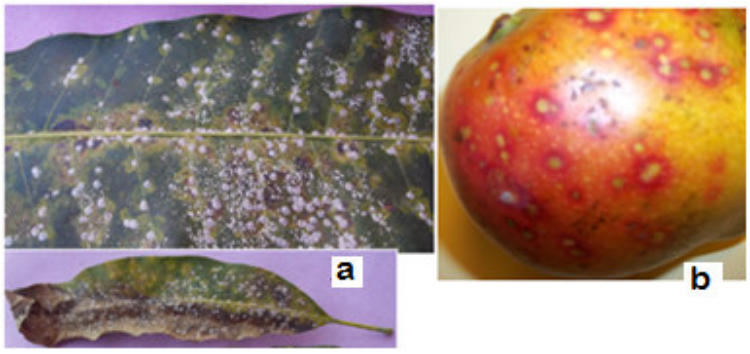

Figure1. Heavy infestation on leaves and consequent wilting (a) and Pink blemish on infested ripe mango fruit (b), (Ofgaa and Emana, 2015)

Materials and methods

Study area

This study was conducted in three mango growing counties of eastern and central Kenya. Two counties i.e., Murang'a and Kiambu from central Kenya and Machakos from eastern Kenya were covered in the survey. In Murang'a County the survey area was extended from Samuru village at 00° 59.62′S and 037° 04.89'E to Chamba at 00° 47.98′ S and 037° 15.79′E while that of Machakos County was between Mananja and Kiimani villages at the 00° 48.10′S and 037°15,80′E, and 01° 10.06′S and 037° 30.25′E respectively. The survey area within Kiambu County was between Kilimambogo and Neema villages at 01° 03.70′S and 037° 14.40′E, and 01° 03.69′S and 037° 17.21′ E, respectively.

Design and procedure of data collection

Households and their respective mango orchards with a minimum of 10 mango trees were considered, and information was gathered by the use of questionnaire from the owners. Proportionate stratified sampling method was followed in such a way that 35 mango fields/households from Murang'a, 25 from Machakos and 15 from Kiambu were considered and hence a total of 75 orchards/ households were addressed. This was according to the proportion of average weight of mango produced from eastern and central Kenya whose ratio was reported to have been 6.9 to 1 respectively (HCDA, 2008). Both open-ended and close-ended questions were used to gather information from mango growers regarding the purpose and practices of mango growing, knowledge about white mango scale and its impact on the fruit market, and management practices of white mango scale. Face-to face survey of door-to-door approach method was conducted to gather information from the respondents while they were in their respective mango fields.

Within each orchard of survey, one mango tree was selected from more or less the most central point of the orchard and 10 leaves from the canopies of each mango tree were collected. Three leaves from the top, 3 from the middle and 4 from the lower canopies were picked and the presence or absence of female white mango scale observed by use of hand lens on both upper and lower surfaces. When present, the number of the pest on every leaf was recorded. Severity of infestation was categorized as follows:

0 = 0 female white mango scale, no infestation
1= 1-5 female white mango scales, mild infestation
2= 6- 10 female white mango scales, high infestation, and
3 = > 11 female white mango scales, very high infestation.

During the survey, the coordinates of each survey site were recorded by the use of GPS.

Data analysis

The data from the survey questionnaire were analyzed by descriptive statistics with SPSS software, version 20.Average number of female white mango scale on the leaves was summarized as mean and standard deviation, to show the pattern of level of infestation in every county. The severity of infestation was shown from the average of the numbers of female white mango scale of all the leaves observed within every orchard. Distribution map was drawn by GIS Visualizer software from the GPS file using the recorded coordinates of each survey site.

Results

Purpose and practice of mango growing

Sixteen percent of the respondents indicated that mango growing started in an unknown long time far before they could know and has continued till now. Moreover, 22.7% said that it has also been continuing within the last 10 and below years. The trend of growing new mango plantation didn't show much increase since 20 years (Figure 2). Moreover, it was observed in some mango fields that new mango trees were grown far apart from each other whereby most of the plots were occupied by other crops (Figure 3).

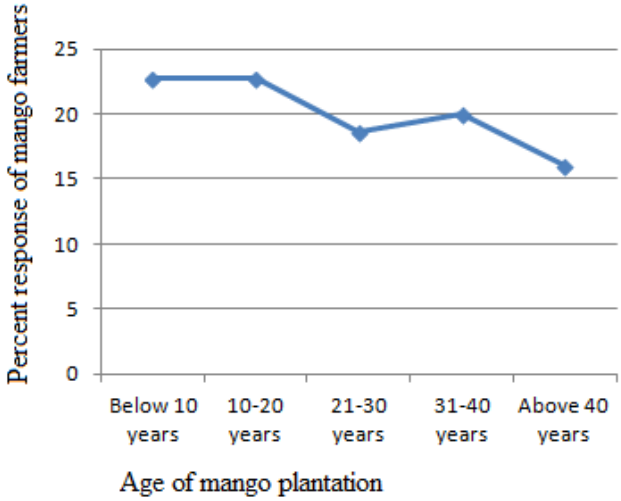

Figure 2. Trend in growing new mango plantations

Figure 3. Intercropping of mango and beans near Sofia, Machakos County

Alphonso, Apple, peach, Tommy Atkins, Boribo, Irwin, Terpentine, Haden, Kent, Ngoe, Sabine, Sensation, Van dyke were indicated to have been the mango varieties commonly grown in the area. It was found out that Apple mango and Tommy Atkins were the first and second most favoured varieties respectively. About 68% of the respondents preferred growing more of Apple mango mixing with other varieties in small proportions. Sensation was the least (1.3%) favoured variety. Only 2% of the respondents couldn't tell the names of varieties of their mangoes, whereas 15% could categorise all the non exotic varieties as indigenous or local mangoes. The field area and number of mango trees owned by the households greatly varied (Table 1).

Table1. Size of mango orchard and number of mango trees in the fields

Possession	N	Minimum	Maximum	Mean ±SD
Field area of mango plantation (hectare)	75	0.15	5.00	0.99±0.83
Number of mango trees in the areas mentioned above	75	10	293	50.15±40.65

The respondents said that mango was grown in the survey area to have served specific purposes i.e., 86.6% as source of income and for family consumption, 10.7% for family consumption only and 2.7% solely for source of income. The respondents indicated that their markets for mango fruits were the whole sellers, domestic mango processing companies, retailers and direct consumers. It was said that wholesalers and retailers comprised 68.1% of the markets whereas domestic mango processors comprised only 8%. The rest of the market was comprised of direct consumers. The mango growing community complained that they couldn't get reliable market that readily absorbed their harvest and hence the income expected from mango was decreasing from time to time (personal communication with Mr John, a mango farmer at Kiimani village). It was known that mango was neither exported nor processed directly by the growers.

Knowledge about white mango scale and its impact on the fruit market

Majority of the respondents said that they knew white mango scale for considerable period of time (Table 2).

Table 2. The period of time since white mango scale has been known in the survey area

For how long known white mango scale	Frequency	Percent
Below 10 years	35	46.7
10-20 years	9	12.0
21-30 years	6	8.0
Not aware	25	33.3
Total	75	100.0

Among the respondents who were familiar with white mango scale, 86% said it caused some damages to mango whereas 14% said that they didn't notice any damage posed by white mango scale. The damages that the respondents believed to have been caused by the pest to mango plantation were spots on fruits, yellow spots on leaves, drying and falling off of leaves, and drying of young twigs. The respondents reported that all the mango varieties were affected by white mango scale but some stressed that the damage to Apple mango was more serious than other varieties. Among the respondents who were familiar with white mango scale and said it caused damages to mango plantation, considerable percentage said that level of the damage showed variations over time since first recognized. Accordingly, the level was said to have been increasing (37.21%), decreasing (27.91%) and showed no difference (34.88%).

Asked to have responded on whether the damage of white mango scale affected the income they got from selling mango fruits, 23.26% of those who produced mango for market said that it affected their income, 39.53% said not affected and 37.21% said they were not aware. All of those who pointed out that the pest affected their incomes mentioned that market resistance of infested fruits (less marketable) and expense of control of white mango scale were the factors that affected their incomes. 8% said that the market resistance was almost always whereas 5.3% said it was encountered only sometimes. The respondents who said their income was affected due to control expenditure pointed out that 13.3% of the income they earned from sell of mango was spent for this expense. However, the rest of the respondents said they didn't know the amount in figure. Some mango fruits of varied varieties which were infested by white mango scale and developed pink blemish and some with live female white mango scales were observed in an open fruit market around Kenyatta Road (Figure 4).

Figure 4. Mango fruits damaged by white mango scale (displayed in open market for sell by a fruit retailer, December 19, 2015)

Distribution and severity of white mango scale

Distribution of the pest covered almost all of the villages surveyed in the three counties (Figure 5). Heavy

infestation of white mango scale was observed on mango leaves in some of these villages (Figure 6). Summary data revealed that the pattern of distribution among the villages of every county showed some degrees of variation (Table 3).

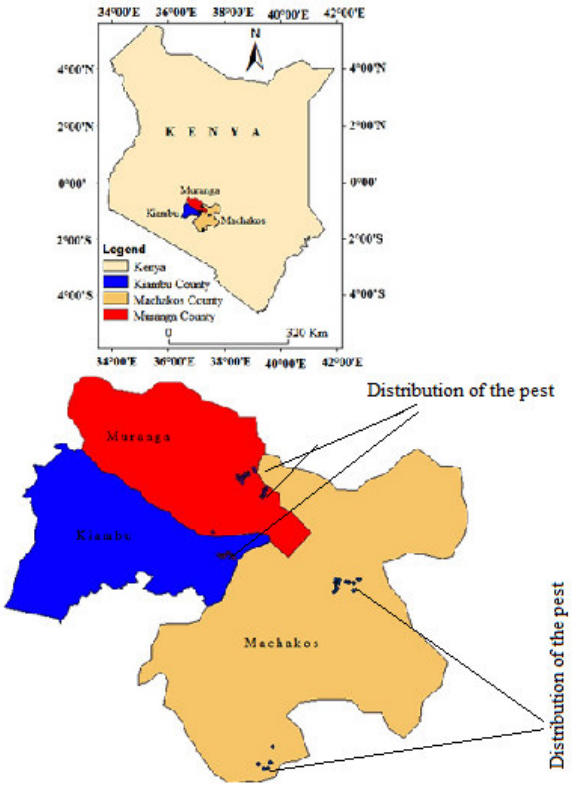

Figure 5. Distribution of white mango scale in the study area

Figure 6. Heavy infestation of the pest on leaf, Chamba village in Murang'a (a) and Kekwaa village in Machakos (b); (Picture taken by Ofgaa 2015)

Table 3 Mean number of white mango scale on leaf in each county

County	Frequency	Mean±SD	Minimum	Maximum
Kiambu	15	1.35±.81	0.4	2.9
Machakos	25	2.75±3.17	0	14.8
Murang'a	35	1.47±1.49	0	14.8

Kiambu County

All of the villages in Kiambu County exhibited mild infestation. It was in only one instance that 10 female white mango scales were recorded from a leaf in Magogoni village.

Machakos County

No infestation was observed in Kauukuni-1 (01°08.64'S and 037°29.38'E) and Kithyoki-2 (01° 10.25'S and 037° 26.67'E) villages in Machakos. Kauukuni-2 (01° 08.578'S and 037° 29.19'E), Mukalala-1 (01° 08.66'S and 037° 30.20'E) and Mukalala-2 (01° 07.95'S and 037° 30.85'E) villages showed high severity status. In Kekwaa village (01° 07.98'S and 037° 31.19') very high severity status was recorded. In this same site on three separate leaves

20, 21, and 25 female white mango scales were recorded. Severity statuses in all of the rest of the villages in Machakos were found to have been mild.

Murang'a County

No infestation was recorded in two villages i.e., Kaseve-1 (00° 49.33'S and 037° 14.41'E) and Githima-1(00° 53.26' and 037° 13.83'). The severity status at Chamba villages (00° 47.98'S and 037° 15.79') was high. All of the remaining 32 villages in Murang'a County showed mild infestation**.**

Management practices of white mango scale

About 57.33% of the respondents said they attempted to control white mango scale by the use of pesticides, agronomic practices (regular pruning) and indigenous practices such as scouting and removal of infested parts of mango plant. The main pesticides used by the respondents included Folimat, Actara, Applaud chemicals and white oil. For the question asked to have known whether it could be possible to control white mango scale, the respondents who exercised control methods gave their responses as indicated below (Table 4).

Table 4 Response on success of the control methods

Successfulness in controlling pest	Frequency	Percent
Yes	6	13.95
To some extent	3	6.98
No	8	18.60
Not aware	26	60.47
Total	43	100.0

Discussion

Mango growing has been a common farming practice since time immemorial. It has been continuing to date in the study area. However, it looked that the rate at which mango growing increased lagged since the last 20 years. Mango product has played significant roles in the lives of the farming community as it served mainly in generating income. The fact that the names of mango cultivars were known by most of the farmers and that they preferred some cultivars more than others might mean that the growers were inquisitive to the crop and had good experience and indigenous knowledge of selecting the varieties which were promising to their purpose of producing it. Griesbach (2003) states that mango was known to have been cultivated in coastal areas of Kenya for centuries. This was an indication that mango has been naturalized in the land since long ago. Apple, Batawi, Boribo, Dodo and Sabine were described as cultivars of Kenyan origin (http//:www.worldagroforestry.org; Griesbach, 2003).

The fact that the possession of number of mango trees showed big variation among the households compared to that of the field areas, as could be seen from the mean and standard deviation (Table 1 above), might indicate that the crop was sparsely planted in the fields of some of the households. This was probably an indication of a trend of decrement in mango production in relation to market problem and diminishing land sizes. The study area being found in a more or less similar agro ecological zones meant that the mangoes also matured at the same time thus saturating the market with fruits. The mango growing community complained that they couldn't get reliable market that readily absorbed their fruits and hence the income expected from mango was decreasing from time to time (personal communication with Mr John, a mango farmer at Kiimani village). There was no individual farmer who was processing mango fruit or exporting mango fruit privately in the study area.

The awareness regarding the presence of white mango scale and its damage on mango plantation in the study area were increasing with considerable proportion since the last 30 years. The impact of the pest was known to have been negatively affecting the return that mango growers would have earned from mango fruit market. This was because of market resistance of mango fruit because of the noticeable colour change on ripe mango fruit infested by the pest and control expense invested on the pest. It could be possible to anticipate from this episode that the pest would pose more and more challenges to mango production if ignored any more. The history of white mango scale reveals that it spreads within few years after first appearance on mango and becomes one of the most challenging mango pests wherever recorded on the crop (Labuschagne *et al*., 1995; El-Metwally *et al*., 2011; Abo-Shanab, 2012; Bautista-Rosales *et al*., 2013; Temesgen, 2014; Ofgaa and Emana, 2015).

White mango scale was distributed within the three counties with severity status from mild to very high level. The concern and implementation of controlling methods were also found to have been at different stages across the orchards. The farmers were not at similar levels of skill and knowledge in controlling the pest. These were reflected by extreme dispersion of recorded numbers of female white mango scale and their severity in the fields, mainly in Murang'a and Machakos Counties. Despite its gradual emergence as potential threat, there has been rare or no documented literature that showed works done on white mango scale in Kenya. Moreover, even though it was known from this study that farmers have been using some pesticides to have

controlled the pest, there has been no recorded document as to which of the pesticides showed more efficacies to control it.

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