MINISTRY OF AGRICULTURE & LIVESTOCK DEVELOPMENT

TECHNICAL TRAINING MANUAL ON THE MANAGEMENT OF PERSEA MITES IN AVOCADO PRODUCTION IN KENYA

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Ministry of Agriculture and Livestock Development Cathedral Road, Nairobi
P. O. Box 30028-00100 Kenya
Telephone: +254-20-2718870
E-mail: info@kilimo.go.ke

PREAMBLE

Kenya's horticulture sector is a major economic pillar contributing 33% of GDP and supporting over 4 million jobs. The area under horticulture increased from 455,086 Ha in 2022 to 464,522 Ha in 2023, representing a 2.1 % rise. The production decreased by 332,932 MT a 4 % drop while the value increased by KES 30.9 billion indicating a 17 % increase compared to the value achieved in 2022. In 2023, the area under fruit production increased by 3.6 %from 225,525 Ha in 2022 to 233,695 Ha. Fruits volumes increased by 1 % while the value increased by 29 % from KES 86.3 billion in 2022, to KES 111.7 billion.

Kenya's avocado industry demonstrated robust growth in 2023, with production reaching approximately 632, 953 metric tons, of which 114,033 metric tons (21%) was exported. This export volume translated into an impressive KES 19.1 billion in value, marking a 18% increase from the previous year. The avocado sector is not only important for export earnings but also provides numerous employment opportunities and contributes to food and nutrition security, particularly for smallholder farmers. This is in line with the country's long term development strategy, the Kenya Vision 2030, and the Bottom-Up Economic Transformation Agenda (BETA) that emphasize the role of agriculture in the economy. Under the Vision, Agriculture is one of the key economic sectors expected to drive the country's economy to the projected 10% annual economic growth. The Fourth Medium Term Plan (MTPIV) 2023-2027 that implements the Bottom-Up Economic Transformation Agenda (BETA), identifies Agriculture as one of the core pillars that will bring down the cost of living, eradicate hunger, create jobs, and foster inclusive growth.

Despite this positive trajectory, the avocado value chain faces significant challenges, including stiff competition from other major avocado-producing nations like Mexico, Peru, Colombia, Chile, and South Africa. With the stringent international market requirements, other challenges include; limited access to clean planting materials, harvesting of immature fruits, infestation by pests and diseases such as Persea mites, false codling moth (FCM), fruit flies, anthracnose and phytophthora root rot.

A native of Mexico, the new avocado pest, **Persea mites,** was first detected in Nakuru County in November 2023and currently has spread to many of the avocado growing counties in Kenya. The pest aggressively attacks leaves hence damaging and reducing photosynthetic surface area thereby weakening the tree and making it more susceptible to other pests and diseases. High mite densities (»500 per leaf) and subsequent feeding can cause partial or total defoliation of trees. Defoliation can lead to sunburn on the fruit, impacting negatively on fruit quality and yield.

Being a new pest, no protocol for the control has been developed in the country. The purpose of this manual is to give basic direction in the control of the pest. The training manual elaborates on identification, biology and ecology of the pest, how to manage, reduce the spread and the role of stakeholders in the avocado value chain.

The success of the management of the Persea mite calls for the effort of all stakeholders and the goodwill of the players in the Avocado value chain. This manual is intended to be a guide that may be improved with new information.

ACKNOWLEDGEMENT

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ACRONYMS

AFA- Agriculture and Food Authority

HCD- Horticulture Crops Directorate

TMA-Trademark Africa

FPEAK-Fresh Produce Exporters Association of Kenya

FPC-Fresh Produce Consortium of Kenya

EU- European Union

FAO- Food and Agriculture Organization

FAOSTAT -Food and Agriculture Organization Statistics

FCM -False Codling Moth

GDP- Gross Domestic Product

IPM- Integrated Pest Management

MAPS- Medicinal and Aromatic Plants

PCPB -Pest Control Products Board

UAE- United Arab Emirates

CHAPTER 1: INTRODUCTION

1.1 Horticultural Crops Production in Kenya

The horticultural crops sub-sector is composed of four categories; flowers, vegetables, fruits, herbs and spice. The sub-sector is a major contributor to food security, income earner to the majority of small-holder farmers, foreign exchange as well as supporting the growth of other sectors through provision of raw materials for agro-processing. Over the years, Kenya's horticulture industry has expanded markedly fueled by the success of crops like roses, avocados and French beans and by the adoption of advanced technologies. The sector has also benefited from strengthened policies, enhanced institutional capacity, and improved mechanisms for developing and disseminating new technologies yet, its share of national GDP has only edged up slightly.

In 2023, the area under horticultural crops production increased to 464,522 Ha from 455,086 Ha which was achieved in 2022, representing a 2.1 % rise. The production decreased by 332,932 MT a 4 % drop while the value increased by KES 30.9 billion a 17 % increase compared to the value achieved in 2022. The highest increase in value was from fruits, herbs and spices whose value increased by KES 25.4 billion and KES 5.8 billion respectively.

TYPE	2022			2023			%
	Area (Ha)	Volume (Tons)	Value (KSh)	Area (Ha)	Volume (Tons)	Value (KSh)	
Fruits	225,525	4,214,620	86,262,986,161	233,695	4,241,602	111,677,741,264	52%
Exotic Vegetables	164,478	3,209,165	78,230,118,348	177,024	2,886,971	79,369,890,933	37%
Indigenous Vegetables(ALV)	48,308	307,324	10,615,283,760	36,230	247,079	8,716,463,881	4%
Aromatic Plants	13,681	192,452	8,457,593,597	14,579	207,126	14,289,604,877	7%
Asian Vegetables	3,094	37,917	1,171,807,009	2,994	45,768	1,605,177,203	1%
Total	**455,086**	**7,961,477**	**184,737,788,875**	**464,522**	**7,628,546**	**215,658,878,158**	**100%**

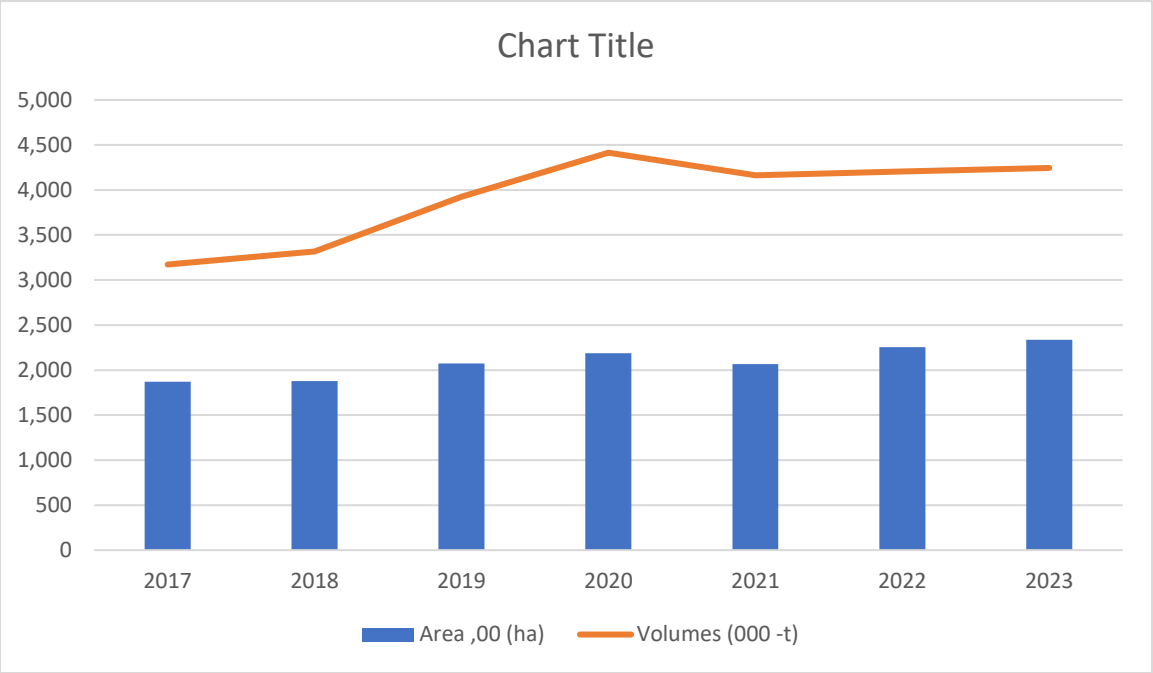
Table 1.1 : Validated Horticultural Crops Report 2023

1.2 Fruit Sector in Kenya

The fruit sector has experienced consistent growth in terms of cultivated area, total production and productivity in recent years. Between 2017 and 2023, the area under fruit cultivation expanded by approximately 25%, rising from 186,928 hectares to 233,695 hectares. During the same period, fruit production increased notably from 3.17 million tonnes in 2017 to 4.24 million tonnes in 2023. Fruits contributed 7% to the Gross Domestic Product (GDP) of total horticulture exports (Economic Survey 2019).

Murang'a County leads in fruit production contributing 17% of the sector's fruit value followed by Lamu at 10% and Meru at 9%. Other key fruit-producing counties included Nyamira, Makueni, Kisii, Taita Taveta, Kirinyaga, and Kiambu.

Fig 1.1: Area, production of fruits (2017-2023)



Source: Horticulture validated report 2023

1.2 Avocado Production in Kenya

Kenya is the leading producer of Avocado in Africa and is the 6th globally in production and export. Avocados accounted for 23% of the total fruit value and 11% of the overall horticultural production in Kenya in 2023. The area under avocado cultivation grew by 22%, rising from 25,669 hectares in 2022 to 31,373 hectares in 2023. Production volume saw a 43% increase from 441,594 tonnes in 2022 representing a productivity index of 17.2MT/Ha to 632,953 tonnes in 2023, which is a productivity of 20.17 MT/Ha. As a result, the value of avocado production nearly doubled, jumping from KES 12.5 billion in 2022 to KES 23.7 billion in 2023—an 88% increase. This growth is attributed to the expansion of avocado farming into new regions in Kenya driven by rising demand in international markets. The fruit is grown in all counties except in the arid and semi-arid lands. According to the Horticulture Validated Report 2024, Murang'a county is the leading county in Kenya in avocado production in the year 2023.The report indicated that Murang'a County accounted for 24.7% of the produce value followed by Kisii (11.5%), Nakuru (10.6%), Nyeri (6.0%) and Kiambu (5.8%) as provided in the table 2 below.

Table 1.2: Production of Avocado by County in Kenya, 2022-2023

County	2022			2023			%
	Area Ha	Volume Tons	Value KSh	Area Ha	Volume Tons	Value KSh	
Murang'a	6,208	121,450	2,921,894,462	6,931	200,991	5,868,074,633	24.7%
Kisii	1,891	60,743	1,416,201,000	2,053	74,904	2,725,505,000	11.5%
Nakuru	2,069	30,594	1,566,492,500	2,893	39,484	2,509,210,000	10.6%
Nyeri	685	11,171	397,958,666	1,981	33,556	1,421,860,000	6.0%
Kiambu	1,830	33,982	1,166,996,200	2,050	44,559	1,366,298,292	5.8%
Trans Nzoia	380	8,932	397,460,000	768	27,418	1,354,196,000	5.7%
Kirinyaga	713	15,935	401,740,000	871	19,647	1,349,142,000	5.7%
Nyamira	1,486	37,476	670,190,000	2,571	47,483	1,322,926,000	5.6%
Nandi	405	4,818	193,556,000	511	16,747	920,192,000	3.9%
Uasin Gishu	775	7,384	480,694,454	1,308	11,980	889,698,000	3.8%
Meru	2,554	21,730	566,235,111	2,486	28,123	878,922,600	3.7%
Embu	585	15,650	313,000,000	680	14,900	447,000,000	1.9%
Baringo				250	6,445	331,875,000	1.4%
Taita Taveta				404	10,095	302,600,000	1.3%
Elgeyo Marakwet				310	5,056	251,360,000	1.1%
Bungoma				235	5,210	204,200,000	0.9%
Migori				526	7,228	185,371,000	0.8%
Machakos	447	3,670	193,950,000	494	4,370	175,850,000	0.7%
Narok				429	4,207	123,930,000	0.5%
Kajiado				371	2,740	117,750,000	0.5%
Bomet	559	9,120	434,971,375	82	1,609	113,623,200	0.5%
Nyandarua				139	2,658	88,922,800	0.4%
Busia				217	2,486	87,900,000	0.4%
Laikipia				471	2,126	84,020,000	0.4%
Vihiga				168	1,978	83,280,000	0.4%
Tharaka Nithi				134	2,395	79,025,000	0.3%
Makueni				387	3,751	75,738,242	0.3%
Kakamega				611	2,488	67,175,352	0.3%
Homa Bay				200	1,440	60,200,000	0.3%
Kericho				166	1,042	47,826,464	0.2%
Kitui				359	1,701	44,640,000	0.2%
Siaya				124	1,357	43,715,000	0.2%
Kisumu				46	1,005	38,115,000	0.2%
W.Pokot				59	886	30,600,000	0.1%
Nairobi				72	761	24,750,000	0.1%
Total	**25,669**	**441,594**	**12,594,669,689**	**31,373**	**632,953**	**23,722,146,583**	**100%**

Source: Horticulture validated report 2023

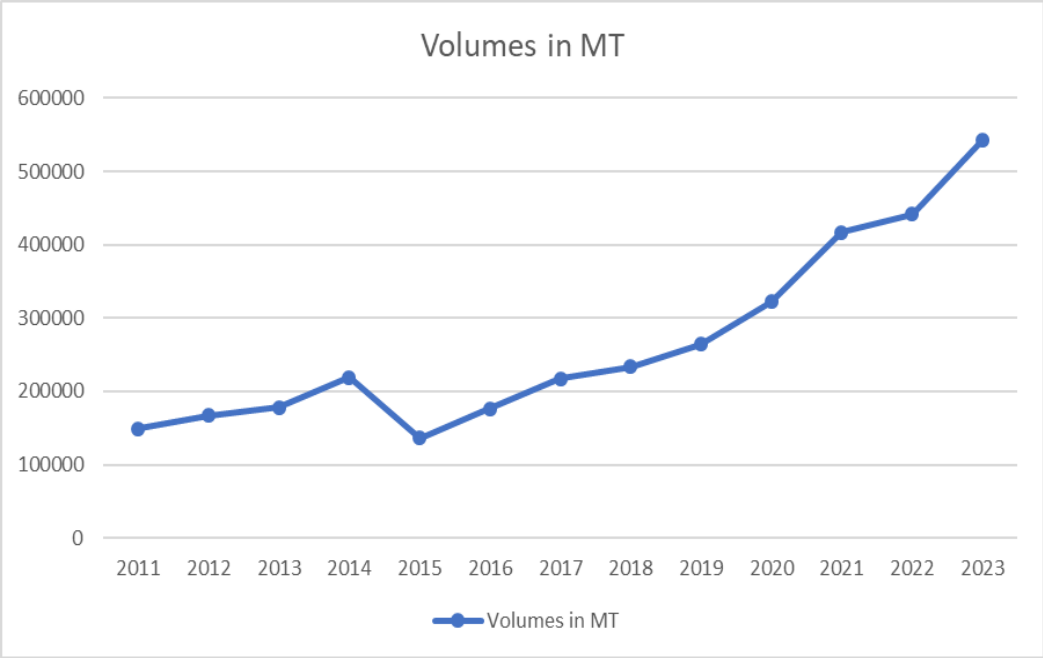
Avocado production holds immense importance for Kenya's economy and its communities, serving as a significant driver of national income and a vital source of livelihood for many smallholder farmers.

The number of farmers producing avocados in Kenya are 966,976 *(2019 Kenya Population and Housing Census).* Smallholder farmers produce an estimated 70% of Kenyan avocados. The avocado smallholder, on average, has 10-20 trees per homestead and constitutes a greater percentage of the estimated 136,623 known avocado commercial farmers. Of these, 130,424 are smallholders, 6,114 are medium holders, and 85 are large.

Furthermore, the increasing global demand for Kenyan avocados provides a stable and growing market, diversifying agricultural income streams and enhancing food security for many

households. The emphasis on high-quality varieties like Hass and Fuerte, coupled with the exploration of new markets, positions Kenya as a one of the major players in the global avocado trade, reinforcing its agricultural prowess and contributing significantly to foreign exchange earnings.

Fig 1.2: Avocado Production in Tonnes trends from 2011 to 2023



Source: FAOSTAT 2025

1.3 Marketing of Avocado in Kenya

Kenya's avocado industry demonstrated robust growth in 2023, with production reaching approximately 632,953 metric tons, of which a significant 114,033 metric tons (21%) was exported. This export volume translated into an impressive KES 19.1 billion in value marking a 18% increase. The sector is primarily driven by the Hass variety, accounting for 70% of exports, followed by Fuerte at 27%, with other varieties like Pinkerton, Carmen, and Jumbo contributing 3%. The European Union remains Kenya's largest market, absorbing 54% of exports through key countries such as the Netherlands, France, Spain, and Turkey, while the Middle East (United Arab Emirates, Saudi Arabia, Qatar, Bahrain) accounts for 32%. Kenya is actively exploring emerging markets in Eastern Europe, North Africa, China, and the Far East.

Despite this positive trajectory, the avocado value chain faces significant challenges, including stiff competition from other major avocado-producing nations like Mexico, Peru, Colombia, Chile, and South Africa. Other challenges include; stringent international market requirements, limited access to clean planting materials, harvesting of immature fruits, infestation by pests and diseases such as Persea mites, false codling moth (FCM), fruit flies, anthracnose and phytophthora root rot.

1.4 Pests and Diseases

In Kenya, the avocado value chain is threatened by major diseases such as anthracnose, avocado root rot and bacterial canker and the sunblotch viroid. There has been an upsurge of both existing (Fruit flies, Scales, Thrips), new and emerging pests such as False Codling Moth (FCM) and Persea mites. This may lead to a negative impact if appropriate control measures are not put in place. Currently, Persea mite has become of great economic importance in the value chain and necessitates immediate action. This is an invasive pest that if not controlled would jeopardize the robust avocado industry.

CHAPTER 2: BIOLOGY AND ECOLOGY OF PERSEA MITES

2.1 Origin and Spread

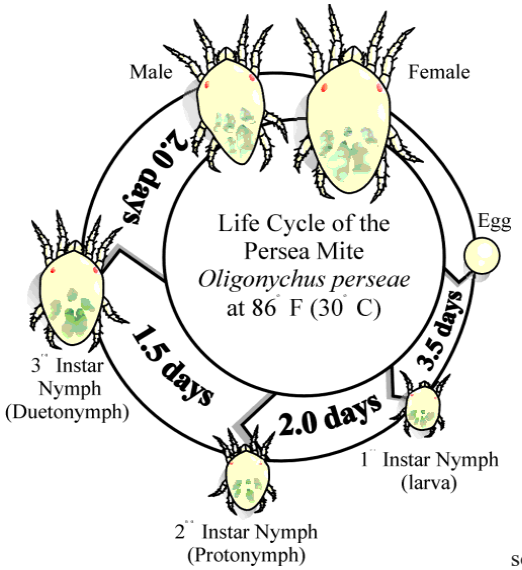
Persea mites *Oligonychus perseae* (Acari: Tetranychidae) are tiny arachnids that feed on avocado leaves, causing damage in the form of necrotic spots and defoliation. The mite, is an invasive pest that was first described in Texas USA with its origin from avocado imports from Mexico (Hoodle 2000). The pest has been described in several countries since then including Costa Rica, Israel, Portugal, Spain and Italy. The pest has only been reported once in Africa, in Morrocco (EPPO 2012). In Kenya, the mites were first observed and detected in Nakuru County in November 2023. Since then, the mite has spread significantly to other counties.

2.2 Life Cycle of Persea Mites (*O. Perseae)*

The Persea mite undergoes five developmental stages:

i. **Egg**: Laid singly on the underside of leaves within protective silk nests. Eggs are round, pale yellow, and develop red eye spots as they mature.
ii. **Larva**: Six-legged, pale yellow to greenish, emerging from the egg and beginning to feed on epidermal cells of the leaves.
iii. **Protonymph**: Eight-legged, larger than the larva, continues feeding and developing.
iv. **Deutonymph**: Further enlarged eight-legged stage, leading to adulthood.
v. **Adult**: Eight-legged; females are about 0.5 mm long, oval-shaped, slightly flattened, yellowish-green with dark spots; males are smaller and pear-shaped. The adult is the most destructive stage of the mite.

Fig 2.1: Diagram showing the life cycle of the O.perseae



source: University of California

Development from egg to adult can take approximately 15 days at 30°C and up to 40 days at 20°C. The population of Persea mites is usually low during the cold and starts to increase during the warmer months.

2.2 Behavior and Key Traits

2.2.1 Reproduction

Persea mites reproduce by laying eggs, with each female laying about 20 to 45 eggs during her life.

Fig 2.2: A photo showing the Persea mite adults and eggs.

Source: University of California, Credits David Rosen

2.2.2. Feeding Habits

Persea mites feed in colonies on the underside of the leaf. They use their mouthparts to pierce the leaf tissue and suck sap, causing damage to the cells and removing chlorophyll. Their feeding results in circular, yellow to dark brown necrotic spots on the leaves. Severe infestations can lead to leaf wilt and defoliation, exposing trees to sunburn and potentially reducing fruit size and yield.

Fig 2.2: A picture showing the effects of the Mite on the leaf

Source: KALRO 2025, Credits – Samuel Khabi

Source: AFA -HCD 2025, Credits – Antoninah Lutta

2.2.3 Location and Webbing

Persea mites are found on the underside of avocado leaves, often in colonies and on the twigs**.** The mites create a protective webbing around their feeding sites, often appearing as silvery spots on the underside of the leaf along the midrib and the veins.

Source: Samuel Khabi, Credits: National Museum of Kenya

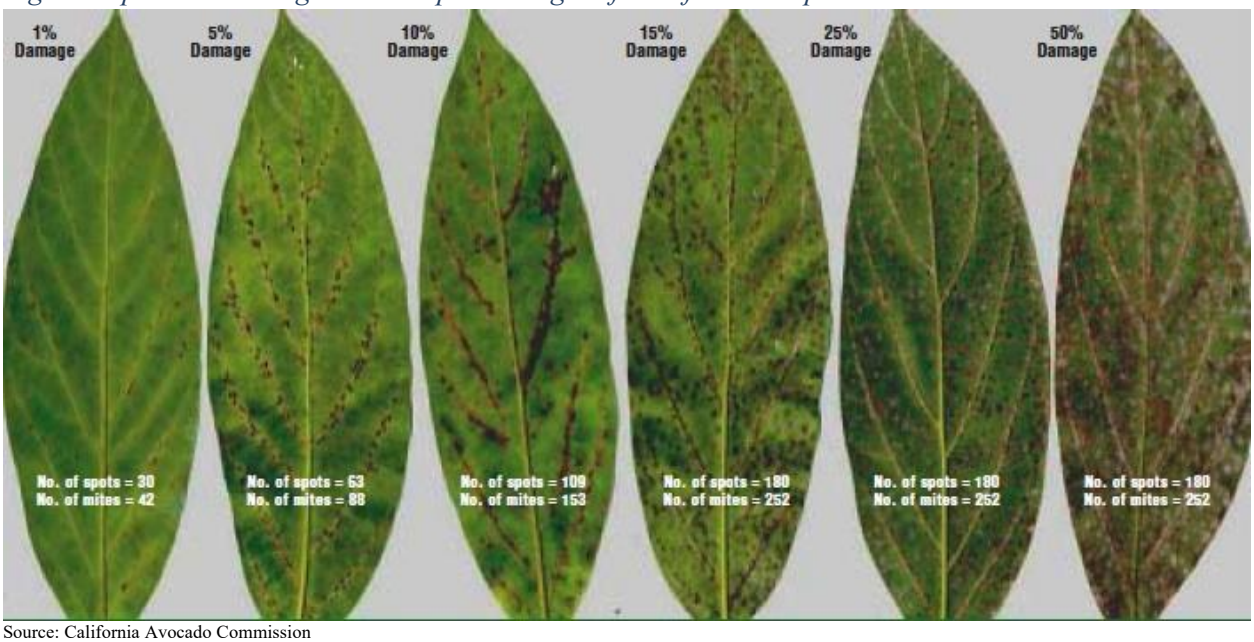
2.2.4 Damage

The feeding effect manifests as small, yellow-brown, rounded necrotic spots, on the lower side of the leaf which can coalesce into larger areas of damage. The effect can be mistaken for a fungal infection or rusts on the upper surface of the leaf. Severe infestations can cause leaves to turn yellow or brown and eventually drop off.

Source: KALRO 2025, Credits – Samuel Khabi

Source: AFA -HCD 2025, Credits – Collins Otieno

Fig2.3: A picture showing the development stages of a leaf under O.perseae attack



Source: California Avocado Commission

2.2.5 Dispersal

Persea mites are primarily dispersed through wind-assisted movement using silk strands and by crawling between plant parts. They can also be spread through human activities like transporting infested plant material, equipment, or fruit. While natural dispersal is limited to neighboring trees, human activity can lead to long-distance spread. The mites stick to garments, farm tools and equipment and spread to other farms.

2.2.6 Population Dynamics

Persea mite populations on avocado trees typically experience cyclical patterns, with population density fluctuating throughout the year. These fluctuations are influenced by factors like temperature, humidity, the availability of food sources, including pollen and new leaf growth. Natural enemies, such as predatory mites, also play a role in regulating mite populations. Mite population drop in cold and rainy season but increase in the warm and dry conditions.

2.3. Host Range

Persea mites, *Oligonychus Perseae*, are known to primarily infest avocado trees (*Persea americana*) but also have a wide host range, feeding on other fruit trees, ornamentals and weeds.

2.3.1. Fruit Trees:

- Avocado (Persea americana) is the primary host.
- Other fruit trees like carob (Ceratonia siliqua), persimmon (Diospyros spp.), and various Prunus species (apricots, peaches, plums, nectarines) can be affected.

- Thompson and Flame seedless grapes (Vitus spp.) are also hosts.

2.3.2 Ornamentals:

- Roses (*Rosa spp.)*
- Acacia *(Acacia spp.)*
- Bamboo (*Bambusa spp.)*

2.3.3 Weeds:

- Milkweed (*Asclepias fuscicularis)*
- Sow thistle (*Sonchus spp.)*

2.3.4 Others:

- Eucalyptus
- Malva spp.
- *Passiflora edulis Sims* (passionfruit)
- *Capsicum spp.*
- Castanea sativa Mill. (on Tenerife Island)
- *Ricinus communis* L.
- *Bidens pilosa* (Black jack)
- Oxalis corniculata

CHAPTER 3: IDENTIFICATION ON PERSEA MITES

It is difficult to detect presence of the Persea mites through mite observation because of their small size. Therefore, Persea mite presence can be detected from the effects and damage resulting from infestation and identified based on the signs and symptoms.

3.1: Signs And Symptoms of Persea Mite Infestation

Circular Spots

Persea mites can be detected by distinct, circular, yellow to dark brown necrotic spots scattered along the veins and midribs on the underside of avocado leaves. The spots become visible through the upper surface of green leaves on trees.

Fig 3.1: A picture showing circular spots of persea mites on leaves in Kenya

Source:Lydia Koitie-Baringo County

Source:Mutitu Caroline- Kisii County

Bronzing

Bronzing effect is a gradual change in colour to reddish brown. In avocado, the leaves turn from green to yellow to reddish brown resulting to light colored canopies upon heavy infestation.

Fig3.2 : Bronzing effects on the avocado leaves with persea mite in a nursery

Source:Lydia Koitie-Baringo County

Source:AFA 2025, Credits Collins Otieno

Webbing

Protective and densely woven nests develop along the midribs and veins on the lower side of leaves which appear as silvery spots. The mites lay eggs in the web.

Fig3.3: Silvery spots on the underside of the leaf.

Source:Lydia Koitie-Baringo County

Source:AFA 2025 – Credits, Antoninah Lutta

3.2 Effects of The Persea Mite Infestation.

Heavy infestation cause defoliation, which leads to sunburned bark and fruits. The trees appear stressed resulting to premature ripening, fruit drop and reduced yields.

Fig 3.4 Defoliation and subsequent sunburn

Source:KALRO 2025, Credits samuel Khabi - Baringo County

Source:Anita Nduku -Makueni County

3.3 Impact of Persea Mite Infestation

Damage caused by Persea mite can weaken the tree making it more susceptible to other pests and diseases. High mite densities (»500 per leaf) and subsequent feeding can cause partial or total defoliation. This leads to sunburn on the fruit, negatively impacting on quality and yield.

3.3 Scouting

Persea mite monitoring requires early detection done by scouting. This should be done after every 7-10 days. Check for the signs and symptoms of infestation by observing the upper and underside of the leaf. To confirm the presence of Persea mite, use any of the methods below:

i. A hand lens and check the underside of the leaf.
ii. Get a leaf and expose the underside to direct sunlight for one minute. Observe the leaf to see movement of the mites.
iii. Sample leaves and shake on a white paper. Observe under the sun to see presence of mites on the white surface.

Note: Management should begin as early as the first instance of the mites is noted.

3.5 Monitoring

Monitoring tool

Use a hand lens (10x-14x magnification) or microscope to examine the upper side of the second major vein (towards the leaf tip).

Monitoring the threshold

Sustainable management requires one to determine the threshold to guide in implementing control measures. Monitoring of the pest threshold is done through the following process:

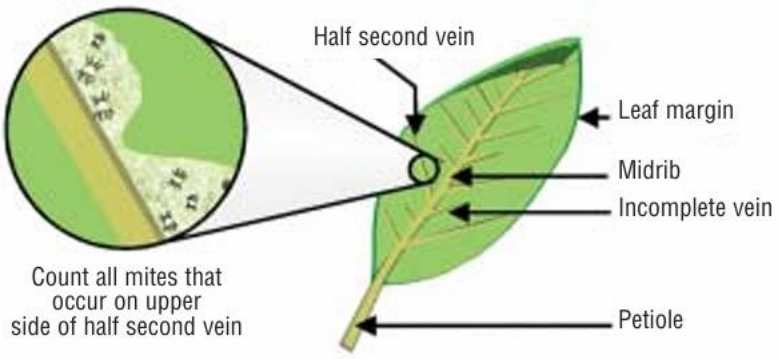
i. **Random Leaf Selection**

- Randomly get a representative sample of trees from the orchard.
- Randomly select a representative sample of leaves from the sampled trees within the orchard (one leaf per tree). Focus on fully developed, leathery leaves from the current season, avoiding those with a reddish tint, as Persea mites are less likely to be present on these.

ii. Estimating the threshold

a) Looking at the underside of each leaf, starting at the petiole end, locate the second major vein that goes strongly from the midrib to the left leaf edge.
b) Examine the upper (towards the leaf tip) vein edge through a hand lens.

Fig 3.5: Estimating Persea mite density (Machlitt, 1998)



c) Count the moving Persea mites adjacent to that upper edge of the second major vein.
d) Count mites in webbed nests or exposed necrotic feeding patches that touch the vein.
e) Count any other mites up against the vein.
f) Do not count the eggs; or any visible mites located away from the vein and outside webbed or necrotic patches.
g) Get the average number of mites by adding all Persea mites counted and dividing the total by the number of leaves sampled.

h) Multiply the figure by 12 to derive the average mites per entire leaf.

Note: When the estimate threshold is 70-100 Persea mites per leaf, pest management should be enhanced.

Alternatively, estimate the number of leaves infested with Persea mites, choose 50 random leaves from several trees and calculate the percentage infestation by multiplying the total number of leaves with one or more motile Persea mites by two (e.g. 15 infested leaves out of 50 is 30% leaf infestation).

Chapter Four: Management Of Persea Mites

Persea mites, being invasive pests, are difficult to control. They have a short life cycle and a protective web which shields them direct contact with pest control products. A wide host range further makes it easier for the mite to survive on alternative hosts during control. In addition, avocado production in Kenya has been done under minimal chemical use. The emergence of Persea mite in the value chain may result in the extensive use of pesticides.

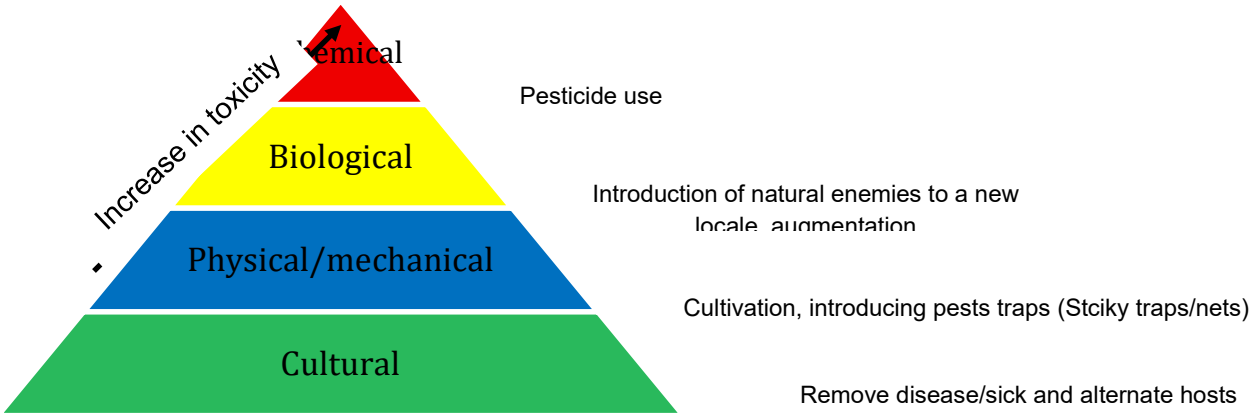
There is no one-fit-all management strategy that is effective against Persea mites. The solution to the Persea mite problem lies in control and management of the pest.

4.1 Integrated Pest Management of Persea Mites

The most effective and sustainable management strategy is the integration of various methods i.e., Integrated Pest Management (IPM). IPM is the careful consideration of all available pest control techniques and subsequent integration of appropriate measures. The goal of IPM is to manage pest populations below economically damaging thresholds while preserving beneficial insects and minimizing environmental impact.

The use of pesticides affects non-target organisms, some of which are beneficial e.g., bees, wasps, ladybirds etc. It is important to supply plants with the required nutrients and water as healthy plants are able to withstand or tolerate pest infestation compared to weak plants which are more susceptible to pest damage at lower population densities.

Fig 4.1:. Illustration on IPM



As illustrated in the above Fig.4.1, Key principles of IPM include regular pest monitoring, the establishment of action thresholds and a holistic approach based Integrated pest management (IPM) promotes sustainable pest management by balancing the use of different methods and minimizing reliance on chemical control alone. This approach improves crop sustainability, reduces environmental impact and optimizes the efficiency of pest management practices. The key principles of IPM include regular pest monitoring, the establishment of action thresholds and a

holistic approach based on the implementation of preventive or suppressive measures for pest management that comprise both farm- and crop-level practices. This includes;

Cultural Control

Effective management of Persea mites require keeping ideal avocado orchard sanitation and practicing Good Agricultural Practices (GAPs) by ensuring;

4.1.1. Regular scouting and monitoring

For scouting and monitoring, use the procedure described in sections 3.3 and 3.5 above. The probability of leaf dropping as a result of Persea mite feeding increases greatly once 7.5-10% of the leaf surface is damaged. Management should begin as early as the first instance of the mite is noted. When the estimate threshold is 70-100 persea mites per leaf, pest management should be enhanced.

4.1.2. Use of pest tolerant cultivars

Avocado cultivars vary in their susceptibility to Persea mite feeding damage. By calculating the average percentage of leaf area damaged by mite feeding, cultivars can be ranked from least susceptible to most susceptible. Pinkerton, Hass and Gwen cultivars have been found to be highly susceptible to the Persea mites' infestations at the rankings of 30.2%, 37.4% and 38.4% respectively. The mechanism by which these cultivars have increased/decreased susceptibility is yet to be established, but it could be related to the leaf sap chemistry or morphology Therefore,farmers should consider tolerant commercial varieties like Lamb Hass.

4.1.3. Removal of alternate host plants

In addition to avocados, Persea mite can develop on a wide range of fruit trees, ornamentals, and weeds. Removal of alternate host plants that act as Persea mite reservoirs should be used in an integrated Persea mite management program.

4.1.4. Use of clean pest free material

The Persea mite is spread to new zones through procurement of infested seedlings. The certification of new and existing nurseries and the routine checks to ensure controlled low levels of pest incidences will prevent introduction and spread into pest free areas.

4.1.5. Use recommended spacing and pruning

Persea mite thrive in dense canopies. Dense canopies create hidden humid zones that provide a favorable micro-climate for the reproduction of the Persea mite. Dense canopies also hinder ease of monitoring and scouting. New orchards should be established at a minimum of 8 m by 8m to allow for aeration and exposure of the Persea mite. Pruning reduces the dense canopies and allows

for the penetration of light onto the leaves. Reducing the canopy increases access of the biocontrol agents and ensures effective spraying of orchards. The pruned plant parts should be properly destroyed.

4.1.6. Proper sanitation and movement of farm tools and equipment

Farm tools and equipment are agents of Persea mite dispersal. Persea mites hitch hike on overalls, fruit tins, harvesting and carrying equipment to new orchards. Equipment used in an infested field, should be cleaned before using in pest free areas. Movement from infested orchards to pest free orchards should be limited and restricted to minimize spread.

4.1.7. Proper feeding (fertilizer) to maintain vigor and resilience

4.1.8. Paint whitewash to control sunburn on the trunk after defoliation

4.2. Physical/ Mechanical Control

4.2.1. Use water sprays to clean under the leaves to reduce mites' infestations (for small orchards/trees)

Persea mites build webs under the leaf surface to protect them from control products. However, evidence suggests that water at high pressure can dislodge mite populations in small orchards. This method is limited in application since costs are only economical under small scale and home use applications.

4.2 Biological Control

4.2.2. Use of natural beneficial insects such as predatory mites

Based on literature, there are commercially available predatory mites with the most potential for controlling Persea mite. Through the Technical Standing committee of Imports and Exports, Kenya can commercialize the available options for use in Kenya.

Experiments have shown that when manually releasing biocontrol parasitoids by introducing small paper cups attached to branches on avocado trees, a minimum of 2000 predators per tree is required to control Persea mite as illustrated in Fig4.1 below.

Fig 4.2: Paper cup attached to branch with binder clip. Predator mites are released into cups from where they disperse into the canopy searching for Persea mites.

4.3 Chemical Control

There are currently no chemicals registered for the control of Persea mite in Kenya. In some instances, Persea mite infestations will be severe enough to warrant chemically based control to reduce damage to leaves and the possibility of defoliation.

Economic threshold levels need to be determined to guide on when to implement the control measures. Frequent use of a limited number of pesticides with similar modes of action (e.g., nerve poisons) can result in the development of resistance. When selecting pesticides to use, low risk pesticides should be given priority. Spot treat individual plants/area to conserve beneficial insects. ***Refer to https://www.pcpb.go.ke/ for registered pesticides for use on Persea mite on avocado in Kenya.***

4.4 Benefits of IPM In Management of Persea Mites in Avocados

- Increased consumer confidence in the safety and quality of avocado fruit thus enhancing market compliance.
- Reliable, stable, and quality avocado yields
- Decreased severity of pest infestations
- Delayed pest resistance or resurgence
- Improved crop profitability due to better pest control measures and appropriate use of crop protection products
- Reduce the potential of interceptions/rejection for avocado destined for export market.

CHAPTER 5.0: ROLE OF STAKEHOLDERS IN MANAGEMENT OF PERSEA MITES

Effective management of new invasive pest require multi-institutional approach. The critical success factors include:

- Stakeholder ownership.
- Effective political leadership and commitment.
- Positioning Migratory and Invasive Pests and Weeds Management Strategy to pivot sustainable pest management initiatives in Kenya.
- Existence of vibrant public and private sectors.
- Establishing an effective institutional framework that links the implementation, monitoring and evaluation and reporting system across the Country.
- Proactive programming for climate change.
- Gender mainstreaming during implementation.
- Leveraging local innovations and inventions.

5.1 Role of Regulatory Bodies (PCPB/KEPHIS/HCD)

- Identify pathways for entry, exit and spread of the Persea mites to other vulnerable areas in the country and institute containment or quarantine measures.
- Create awareness to prevent further spread of the Persea mites.
- Regular monitoring for Persea mites to inform rapid response and containment measures.
- Facilitate, promote and fast-track registration of pest control products for Persea mites' management including Bio-pesticides, Botanicals, and the potential use of native natural enemies.
- Enforce compliance and traceability through inspection, registration, licensing, certification and routine monitoring of value chain actors.

5.2 Role of Research and Academia Institutions

- Carry out countrywide distribution or delimiting, socio-economic and impact surveys to assess the extent of the problem.
- Investigate efficacy of native biocontrol agents and locally available bio-pesticides
- Undertake research for avocado varieties resistant/ tolerant to Persea mites
- Develop an array of cost-effective, clear and harmonized monitoring protocols to be rolled out to smallholders.
- Disseminate research findings

5.3 Role of County Governments

- Provision of extension services

- Create awareness and sensitize farmers and other stakeholders using varied communication approaches.
- Consider efficacy, safety, sustainability, practicality, availability and cost effectiveness of recommended control practices.
- Promote good agricultural practice and low-risk, cost-effective options for management of the Persea mites.
- Reactivate the early warning system in the county to interlink and inform of pest and diseases.
- Constitution and operationalization of sanitary and phytosanitary county committees
- Implementation of policy frameworks.

5.4 Role of National Government

Coordination of Multi-Institutional Technical Team (MITT) with institutions with mandate on new transboundary pests to undertake the following;

- Development and packaging of technical materials.
- Pathological field surveys.
- Training of county technical teams.
- Lobby for procurement of appropriate pest control products.
- Policy formulation and review on invasive and transboundary pests' management.

5.5 Industry Associations and International Partners

- Market Access and Standards: Providing information on international market requirements and assisting farmers in meeting these standards.

- Capacity development: Offering training programs to improve farming practices and pest management strategies.
- Funding and Resources: Supporting initiatives aimed at enhancing the sustainability and profitability of the avocado industry.

5.7 Role of Producers

- Engage with extension service providers, regulators, advisory and information services to obtain latest information on government-approved, recommended pesticide and latest information on Persea mites identification/life cycle and management.
- Use of registered pest control products for Persea mite management.
- Undertake regular surveillance and monitoring for the Persea Mites
- Implement good agricultural practices relating to management of the Persea mites
- Report any new pests and/or diseases in the value chain.
- Source clean planting material from certified producers.

- Maintain good records of agronomy, monitoring, interventions, yield, etc., and review regularly to determine the cost–benefit of the control methods used.
- Farm workers should use the proper personal protective equipment (PPE) when applying pesticides, follow recommended agricultural and cultural practices to manage Persea mites.
- Report cases of ineffective pest control products.

ANNEX

Technical Working Group

Name	Organization	Function	Role
Patrick Musyoki	FPEAK	Technical and compliance	Chair
Samuel Khabi	KALRO	Research Scientist	Secretary/Technical lead
Timon Boen	AFA-HCD	Senior Horticulture officer	Organizing secretary
Wilfred Mwo Yona	AFA-HCD	Crop inspector	member
Florence Njiru	PCPB	Compliance	member
Anita Nduku	PCPB	Compliance	member
Florence Wambua	AFA-HCD	Senior Horticulture officer	member
Allan Kololi	FPC-K	Technical and compliance	member
Amos Melly	MoALD -SDA	MOH	member
Mwangi Zachary	PP&FSD	Principle Agriculture officer	member
Francis Kariuki	Nyeri County	Agriculture county director	member
David Shivonje	Bungoma County	Agriculture county director	member
Onyango Anthony	Nyamira County	Agriculture county director	member
Caroline Mutitu	Kisii county	Agriculture county director	member

Kennedy Maseno	Kisii county	Agriculture county director	member
Sarah Taiwa	Baringo County	Agriculture county director	member
Lydia Koitie	Baringo County	Agriculture county director	member
Vincent Morara	Nyamira County	Agriculture county director	member
Kennedy Ogutu	Migori County	Agriculture county director	member

Pictorials

Persea mite (UCIPM)	Persea mite in Kenya
	
	
	

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