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Original Research

# Assessment of Field Management Practices of Smallholder Farmer's Avocado Production in the Major Areas of Ethiopia

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## Abstract

*Avocado is an economically important crop in Ethiopia, yet its yield and quality remain low due to poor field management practices. To assess and document these practices, a survey was conducted across smallholder home gardens and cluster-based avocado farms in Sidama, South Ethiopia, Oromia, and Amhara regions. Using multi-stage purposive and random sampling, data were collected through field assessments, focus group discussions, and secondary sources. Agronomic practices from transplanting to harvesting were evaluated, and data were analyzed using descriptive statistics. Findings revealed that 66.8% of growers cultivated local avocado types, while 32.25% grew commercial varieties. Among the commercial types, 43.9% planted Hass, and 15.2% planted Ettinger. The annual mortality rate of avocado trees was high, averaging 24.7% for commercial types and 19.9% for local ones. Regarding planting systems, 25% of farmers preferred homestead planting, 24.3% opted for cluster planting, and 21.6% used a coffee-based agroforestry system. Harvesting occurred year-round, although peak seasons varied by region some areas had one peak, while others had two. Overall, the study found that avocado fields were poorly managed at every stage, from transplanting to harvest. This poor management highlights the need for a well-structured field operating system. To ensure sustainable production, enhanced quality, and extended orchard lifespan, coordinated efforts are required from the government and development partners to promote improved field management practices across Ethiopia.*

## Article Information

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## INTRODUCTION

The production of avocados has been on the rise globally for the last decade. According to reports published by FAOSTAT (2020), over the past decade, avocado production has doubled from 4.07 million tons in 2011 to about 8.06 million. Avocado cultivation is best suited to frost free humid tropical and subtropical climates with an average daily temperature of 20℃ to 25℃. The rank of Ethiopia's avocado production status fluctuates yearly. However, based on the recent FAOSTAT, (2020) Ethiopia became the 8th avocadoproducing country globally and the 2nd producer in Africa by producing 245,336 tons in the year specified. It is estimated that more than 11,337,925.00 ha of land is highly suitable for avocado production, whereas more than 19,237,197.00 ha of land is moderately suitable for avocado production indicating avocado fruit is a commodity much potential in Ethiopia and the details of land suitability for each region and zones are presented in this report (Mekonnen *et al*., 2024, Unpublished).

Based on the CSA (2020/2021) report, a total of 30,587.74 ha of land was covered by avocado fruits with 245,335.63 tons of production by smallholder private peasant holdings in Ethiopia. It is reported that there is a 46.52% increase in area coverage and a 134.79% increase in production over the previous year. The Ethiopian Institute of Agricultural Research, Melkassa Agricultural Research Center made registrations of commercial avocado varieties (MoANR, 2008; Edossa *et al*., 2010). Since then, multiple development actors and partners have participated in avocado industry development in Ethiopia.

Over the past six years, avocado exports from Ethiopia have enjoyed steady growth and in 2021, Ethiopia shipped out just above 3,000 tons of fresh avocado fruits. The export volume of avocado fruits from Ethiopia between 2012 and 2021 (CSA, 2021) and there is an increment of nearly 10% from the previous year (*www.freshelaexporters.com/avocado/everything-you-need-to-know-about-avocados-in-ethiopia*). The quantity of Ethiopia avocado exports will continue to increase in the future as many thousands of hectares of land are coming under commercial Hass avocado variety every year in many regional states including South West Ethiopia, Gambella, and Benshangule-Gumuz Regional States.

The exports of avocado fruits from Ethiopia were valued at just above 1 million US Dollars in 2021 (CSA, 2021). Compared to the previous years, there is an increase of nearly 11% **in** export quantity**;** the sharpest climb was from 2014 to 2015 when the export value rose from about

1,000 US Dollars to around 18,000 USD (www.freshelaexporters.com/avocado/everything-you-need-to-know-about-avocados-in-ethiopia).

Almost all avocado production systems in Ethiopia are by the smallholders (CSA, 2021), although some commercial avocado farms are coming up. This smallholder peasant's avocado production system mostly uses unimproved local type with traditional farm management practices using primitive farm implements, harvesting, and postharvest practices. Even if they plant the Hass variety, they use limited modern farm inputs and other farm management practices. These traditional and conventional management practices of both local and commercial varieties resulted in the fruit subsector's poor performance with low productivity trends, less than 8 t/ha q/ha on farmers' fields were recorded (CSA, 201), whereas yields of more than 30 t/ha have been recorded in the research centers (Edossa *et al*., 2023; Edossa *et al*., 2023; Edossa *et al*,. 2010).

The agricultural system as a whole and the avocado fruit production subsector in particular are showing improvement in terms of production areas in Ethiopia. Ethiopia has identified avocado as a high priority agricultural commodity for the Ten-in-Ten national program (MoA, 2021), as result the extent and use of improved varieties, modern farm inputs, and modern farming system practices are in progress. Many governmental organizations such as Ministry of Agriculture EIAR, Agricultural Transformation Institute (ATI), Regional Bureau of Agriculture (RRoA) and most NGOs involved in agricultural development in Ethiopia have supported avocado fruit multiplication since 2016 in various ways. Since then, thousands of grafted seedlings of improved avocado varieties multiplied and were distributed every year. Currently, Oromia and Amhara Regional States have reached maximum hectares of avocado.

Besides smallholders' traditional avocado production, commercial avocado production (cluster production) was recently commenced in Ethiopia. Cluster avocado production in Ethiopia reached more than 20,000 ha of land with 85% Hass, 10% Ettinger and nearly 4% of the other avocado varieties (MoA, 2021). In addition, thousands of ha of land have become under the avocado cluster's commercial production in Ethiopia. Currently, tens of thousands of ha of land are covered by avocado plantations every year in Amhara, Oromia, Sidama, South Ethiopia and South West Ethiopia Regional States where improved varieties of Hass and Ettinger are used under irrigation conditions (Edossa *et al*., 2024). However, a lack of proper field management practices and poor value chain at all stages of the value chain leads to non-productivity and economic loss of the plantation (Berhanu, 2013; Woyessa and Berhanu, 2010). Besides, poor partnerships among the development actors and research, and poor agronomic and field management practices are among the key problems. With all these constraints commercial avocado development has continued with less rewarding outputs. As a result, fruit cluster avocado plantations are not coming to both local and export markets as expected; when coming to the markets, the volume is very low with small fruit sizes and low quality and export status.

There are no national standard avocado production guidelines, and each commercial producer and individual, such as government, private companies and non-governmental institutions, private individual investors, shareholders, religious and non-religious social institutions use different field management practices irrespective of variety, agro-ecology, altitude, age of plantation, tree spacing, the number of rainy days in the area, canopy cover, soil types, ground cover and target yields, and climatic conditions that can provide a good representation of various avocado production systems in the country. Therefore, the objectives of this paper are: 1) to generate information on smallholder avocado fruit orchards and plantation management practices, 2) to identify constraints in avocado field management practices, 3) to align commercial avocado fruit field management requirements along the standard operation procedures, needs of global markets requirements and economic benefits.

## MATERIALS AND METHODS

### Description of the study area

This study was conducted in major avocado-producing and marketing districts. These are Dale (Sidama Region), Boloso Sore (Southern Ethiopia), Kersa and Ada'a (Oromia Region), and Semen Mecha and Jabina Tena (Amhara Region) (Figure 1), all of which have a high potential for avocado production. The suitability study considered the primary environmental factors influencing avocado growth, development, and yield—namely climate, topography, and soil properties—were carefully considered in this study (Mekonnen *et al*., 2024). The criteria specifically included climate (rainfall, temperature), topography (slope, altitude), soil properties (pH, soil depth, texture, drainage), and land use/ land cover (*Anon*.). Thus, these areas fall under moderately suitable and requires some modifications, such as soil pH, slope, etc…this would concede with increasing land scarcity that would force avocado growers to use moderately, less suitable areas in the future. Further reading is available in the avocado feasibility and suitability report (Mekonnen *et al*., 2024).

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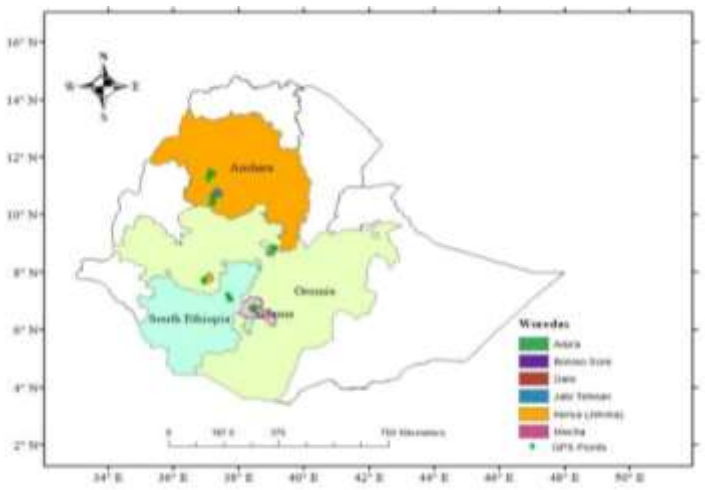


**Figure 1:** Map of the study areas in Sidama, South Ethiopia, Oromia and Amhara Regional States (Adapted from Tamirat *et al*., 2024)

### Data Collection Methods

This study employed a mixed-methods research approach, incorporating both qualitative and quantitative data collection techniques. Primary data were gathered through questionnaires administered to avocado producers, household heads, village and community leaders, local buyers, wholesalers, and retailers. A household survey was conducted with randomly selected target households in the six target Woredas and 12 Kebeles based on a Sample Size proportion to the population principle. Qualitative data were collected using different data collection methods, including key informant interviews, focus group discussions, and document reviews. KII with the government sector office, research organizations, cooperatives, unions, and private ventures participated in the qualitative study.

**Sampling and Sample Size Determination**

Sample selection was done using multi-stage sampling processes. In the first stage, six districts were selected from the Sidama, South Ethiopia, Oromia, and Amhara Regions purposively due to avocado production and marketing potential. In the second stage, from each District, 12 avocado-producing Kebeles were identified. In the third stage, with a required degree of precision about 268 samples of household heads were chosen from each Kebeles. The samples were then distributed to the appropriate Kebeles using a population proportional to the sample size. Accordingly, 268 HHs participated in the household survey from Sidama Region, Dale District (105), South Ethiopia, Boloso Sore District (43), Oromia Region, Kersa and Ada'a Districts (61), and Amhara Region, North Mecha and Jabina Tena districts (59).

**Methods of data analysis**

Both qualitative and quantitative data analysis methods were used to analyze information obtained from HH (Household) surveys, FGDs, KII (key informant interview) observations, and secondary sources. The data collected from the sample avocado producers and traders were analyzed using descriptive statistics, which included mean, standard deviation, frequency, and percentiles. Then, Value chain mapping was used to present and summarize the outcome from grounded theory. The study used value chain analysis, which is particularly effective at tracking product flows, illustrating the actual processes of value-adding, identifying key actors, and their relationships with other actors in the chain, and measuring the distribution of their benefits. The content analysis was performed by transcribing all responses and field notes from field observation, which helped to identify key patterns, trends, themes, and value chain issues in the data.

**RESULTS AND DISCUSSIONS**

**Avocado growing households' characteristics**

The sex, age, educational status of the household head and landholding size of the avocado grower household heads were the determinants for the number of avocado trees owned by smallholder producers (Table 1).

**Table 1:** Effects of some socio-economic factors on the number of avocado trees owned by smallholder producers in the studied area

| Socioeconomic variables | Mean | Standard Deviation | Minimum | Maximum |
|---|---|---|---|---|
| Age of HH head | 45.7 | 12.71 | 24 | 83 |
| Education year | 5.6 | 3.34 | 0 | 21 |
| Experience in fruits growing (years) | 15.2 | 9.68 | 1 | 43 |
| Experience in avocado growing (years) | 13.7 | 8.53 | 1 | 43 |

**Source:** Tamirat *et al*., (2024)

**Experience in fruit growing**

The study showed that among the sample respondents, 16.2% of the farmers had experience in fruit cultivation whereas 83.8% of the growers had no experience in fruit cultivation (Table 1). The history of fruit cultivation is the oldest in South Ethiopia, South West Ethiopia, Sidama, and parts of Oromia Regional States.

**Farming experience in avocado production**

Among the fruit producers, nearly 13.7% of the households had experience of avocado fruit growing, whereas 86.3% of the respondents had no experience in avocado cultivation (Table 1). If technology and information packages with avocado fruits lag , there is a probability that many avocado clusters fail to establish and produce sufficient yields and quality fruits.

**Total land holding of avocado grower households and land allocated for avocado fruits**

The study found that the overall average landholding of smallholder farmers was 1.5 ha; whereas the average irrigated area of the households was 0.34 ha. In addition, the average total area under fruit production was 0.31 ha. Furthermore, the average area covered by the local avocado was 0.12 ha and that of commercial avocado was 0.02 ha (Table 2).

The area coverage by local avocado types was the highest in the Sidama Regional State with an average of 0.21 ha, followed by Oromia Regional State which covered an average area of 0.14 ha of land; however, it was the lowest in the South Ethiopia Regional State where the local avocado types covered an average area of 0.08 ha of land (Table 2). All local and un-grafted avocado trees have large canopies that reduce land availability for other crops. In addition, local avocado types are very tall which is difficult to harvest, and with low fruit quality (Ketema *et al*., 2010). Market prices for these varieties are low; during collection, there is considerable fruit loss when they fall, causing cracks and bruises and hence their rejection. High area coverage of local avocado types indicates that the region has a history of long-time use and it requires replacing these local tree populations with commercial varieties. Each regional BoA should work on strengthening each avocado value chain actor based on the requirements of international market standards.

**Table 2:** Area covered by commercial and local avocado trees in different regions

| Region | Commercial avocado varieties | | Proportion of farmers (%) | Local avocado | | Proportion of farmers (%) |
|---|---|---|---|---|---|---|
| | Mean | SD | | Mean | SD | |
| Sidama | 0.15 | 0.074 | 36.7 | 0.21 | 0.16 | 63.30 |
| S. Ethiopia | 0.08 | 0.011 | 45.8 | 0.08 | 0.05 | 54.20 |
| Amhara | 0.35 | 0.146 | 93.6 | 0.13 | 0.09 | 6.40 |
| Oromia | 0.08 | 0.021 | 39.3 | 0.14 | 0.12 | 60.70 |

**Source:** Tamirat *et al*., (2024)

*Persea americana* M. has been subdivided into three groups comprising the Mexican, Guatemalan, and West Indian horticultural races (Lahav and Lavi, 2012). The races look, taste and even smell different, at the same time they hybridized among themselves easily in Sidama, South Ethiopia, Central Ethiopia, South West Ethiopia, and Oromia Regional states of Ethiopia and currently millions of trees have been generated from these hybrid seeds and descendent trees are available so that trees with desired characteristics of new types (variety) could be easily obtained if these promising trees are multiplied vegetatively. If all the breeding is done to create more and different trees with different characteristics, hopefully, better fruit quality would be obtained. The study showed that there are potentially promising both green and dark-skinned local avocado trees in South and South Western parts of Ethiopia. Currently, seedling trees are crosses and hybrids coming out and if one explores the seedling trees can surely get many new potential commercial and rootstock avocado varieties in Ethiopia.

**Area covered by commercial avocado trees**

The detail area covered by the commercial avocado varieties in all studied regions was assessed, and the highest area coverage was recorded in Amhara Regional State with an average value of 0.35 ha of land, followed by the Sidama Region with an average area coverage of 0.15 ha of land. Oromia and South Ethiopia had the lowest average area

coverage of both 0.08 ha of land (Table 2). Having high areas of commercial avocado varieties indicates that if these areas are well managed along with global market requirements, there could be high income for the farmers as well as it could be an export commodity. Much work is ahead of the RBoA where careful planning should be done to bring those local type avocado growers into commercial types as millions of grafted avocado seedlings are available every year in many regions of Ethiopia. Provision of high-quality seedlings is required through nursery accreditation and nursery seedling certification systems.

**New avocado establishment, number of new avocado seedlings planted, and survival percentage of avocado seedlings**

It is known that many hundred thousand commercial avocado varieties grafted seedlings have been prepared and established every year in many regions of Ethiopia mainly in Sidama, South Ethiopia, Oromia, Amhara, South-western Ethiopia Peoples, and Tigray. However, avocado planting has been carried out usually by a campaign from seedling purchase, collection, loading, transporting, and unloading, until provision to farmers. During these operations, many seedlings lose labels, and get stressed. The pit is prepared not in a proper way ahead of time. Then, the seedlings are planted immediately, while pits should be kept open for a month for perennial crops. Top soils and manure are mixed, and placed in the pit and after a week this pit is opened again and seedlings are planted inside to the level of plastic bags. Campaign planting should be avoided since seedlings are transplanted not in a proper manner and it is the case that many seedlings will not survive.

The survey results showed that the sample farmers planted the highest number of new avocado seedlings in Amhara Regional State where a sample avocado grower planted an average of 20.3 avocado seedlings, followed by Sidama Region where each sample avocado producer planted an average of 14.8 avocado seedlings; while in Oromia Regional State each sample grower planted an average of 8 avocado seedlings (Table 3). In general, the planting of new avocado seedlings should go in line with nursery accreditation and seeding certifications; in addition, proper site selection and field preparations should be implemented. Further, care should be taken to new plantations from the introduction of seedlings from root rot diseases and Persea mite-infested areas through the implementation of nursery accreditation (ES, 2023a) and seedling certification ES, 2023b).

**Table 3:** Mean area, number of new avocado seedlings planted and proportion of improved varieties planted in the study regions of Ethiopia

| Region | Mean area (ha) | No. of new seedlings planted | Improved variety plar |
|---|---|---|---|
| Sidama | 0.27 | 14.8 | 36.7 |
| South Ethiopia | 0.37 | 6.50 | 45.8 |
| Amhara | 0.23 | 19.3 | 93.6 |
| Oromia | 0.12 | 9.40 | 39.3 |

**Source:** Tamirat *et al*., (2024)

The study result showed that Amhara Regional State had the highest survival rate of commercial avocado seedlings, 86.2%, followed by Sidama Regional State where avocado growers had 81% survival rate while Oromia Regional State had the lowest, 66.2% survival rate (Table 4). The low survival rate of plastic potted avocado seedlings indicates poor seedling handling, poor transplanting, and poor field aftercare.

**Table 4:** Survival percentage of avocado seedlings from transplanting in different regions

| Region | Mean | Std. Deviation | Success rate (%) |
|---|---|---|---|
| Sidama | 12.0 | 11.6 | 81.0 |
| South Ethiopia | 8.6 | 8.3 | 79.6 |
| Amhara | 17.5 | 15.8 | 86.2 |
| Oromia | 5.3 | 4.5 | 66.2 |

**Source:** Tamirat *et al*., (2024)

Seedlings with plastic pots are assumed to have the highest survival percentages, however, the low survival rate of grafted seedlings recorded is due to poor seedling quality, poor seedling transportation and handling, improper pit preparations and transplanting, and absence of irrigation water at the end of rainfall followed by mismanagement practices such as the absence of protection from domestic and wild animals after transplanting.

**Type of commercial avocado variety planted by the households**

The selection of avocado cultivars depends mainly on the export market demands**.** Hass avocado variety has unique flavor and taste which is better than those bought from stores. With this intention, the survey results showed that 43.9% of the smallholder farmers planted Hass variety, followed by 15.2% Ettinger variety, and Nabal and Fuerte varieties among the commercial varieties (Table 5). About 21.1% of farmers planted unknown commercial varieties. The study further indicated that there was awareness of planting commercial avocado varieties, and farmers received what was provided to them with the problem of labeling the variety record. The absence of this labeling and record was an issue at all levels at it is required for the GlobalGAP certification. The lack of labeling of varieties in the field and the absence of input documentation created field management complexities, as every variety has its own growth and developmental cycle with corresponding management throughout the study areas (Edossa *et al*., 2023). This study suggested that the development of national and regional avocado databases is important for traceability of each variety and other necessary information.

**Table 5:** Type of commercial avocado variety planted by farmers

| Variety | Number of households | Proportion to sample (%) |
|---|---|---|
| Hass | 75 | 43.9 |
| Ettinger | 26 | 15.2 |
| Nabal | 19 | 11.1 |
| Fuerte | 15 | 8.8 |
| Improved but unknown | 36 | 21.1 |
| Total | 171 | 100 |

**Source:** Tamirat *et al*., (2024)

It is important that through international market demand research, diversifying avocado varieties in Ethiopia is highly required. There are reports indicating smooth-skin avocado varieties such as Bacon and Fuerte are recording a good demand and fairly high prices in some EU countries (www.freshplaza.com/europe/article/9572692/this-year-smooth-skin-avocado-varieties-are-again-recording-a-good-demand-and-fairly-high-prices). These varieties are increasingly appreciated in the market and have a very stable production. These particular varieties are mainly consumed in Eastern Europe – in countries such as Poland, Lithuania, Greece, Romania, or Bulgaria, where the demand for smooth-skinned avocados is quite high and keeps rising every year (*Ibid*). Thus, diversifying commercial avocado varieties is important in Ethiopia targeting domestic consumption, export market, and industrial purposes.

**Preferential areas and cropping system for avocado planting**

The cultivation of avocado fruit has a long history in some areas of Ethiopia whereas it has recently been introduced in some other areas. Where it was introduced a long time like Sidama, Wolaita, and Gede'o areas the cultivation of avocado fruits has been associated with coffee and enset in the homegardens. The survey study found contrasting preferential areas of avocado cropping system among the regions, that in those three Regions such as Sidama, South Ethiopia (Wolaita) and Oromia nearly ½ avocado growers preferred planting avocado trees under coffee-based and perennial crops agro-forestry system whereas 81.4% of avocado growers in Amhara Region preferred planting of avocado by cluster plantation (Table 6). This implies that the crop management techniques required in coffee-based and perennial crops agro-forestry system vary from those required for sole (cluster) avocado orchard/ plantation such as tree spacing, nutrient management, and irrigation water management. Thus, further study should be required for the development of best practices for each production system before blanket (one for all) management practices are recommended for national avocado development.

**Table 6:** Preferential areas and cropping system for avocado planting by the smallholders

| Avocado production system | Regional State | | | | | | | | Average percent (%) |
|---|---|---|---|---|---|---|---|---|---|
| | Sidama | | South Ethiopia | | Amhara | | Oromia | | |
| | Freq. | % | Freq. | % | Freq. | % | Freq. | % | |
| Under coffee-based and perennial crops agro-forestry system | 58 | 55.2 | 19 | 44.2 | - | - | 43 | 56.6 | 52 |
| Avocado sole planting | 16 | 15.2 | 14 | 32.6 | 4 | 6.80 | 10 | 13.2 | 17 |
| Avocado is grown mixed with other crops | 22 | 21.0 | 7.0 | 16.3 | 7 | 11.9 | 16 | 21.2 | 18 |
| Avocado is planted in cluster based | - | - | - | - | 48 | 81.4 | 4 | 5.3 | 43 |
| Avocado is grown around homesteads | 9 | 8.6 | 3 | 7 | - | - | 3 | 3.8 | 6 |

**Source:** Edossa *et al.*, (2024)

Among the sample avocado growers in the study areas, nearly 21.6% of the growers preferred planting avocado under coffee-based agro-forestry system as this production system is common in Sidama, S. Ethiopia, parts of Oromia where coffee production is very common.

**Avocado tree death, diseases and die-back**

The survey assessment found that quite a large number of avocado trees die every year in all regions, as the survey study found that the highest average avocado tree death was 9.3 improved avocado trees from sample farmers in South Ethiopia (Wolaita) Region, followed by Oromia Region where an average of 5.5 trees of improved avocado trees died in the same year (Figure 2). The number of local avocado tree deaths, was highest in Oromia on the average 7.5 trees died in the year from sample farmers, followed by South Ethiopia (Sidama) where an average of 5.3 local avocado trees died in a year. Although avocado tree death is reported by different scholars (Demelash and Getachew, 2015; Berhanu, 2013; Woyessa and Berhanu, 2010) and Mestawet *et al*., (2022) also reported that avocado seedling dies in Lemo Woreda Hadiya Zone, Central Ethiopia due to, eaten by wild animal, domestic animals such as by cows, sheep, and other herbivores feed at seedling phase.

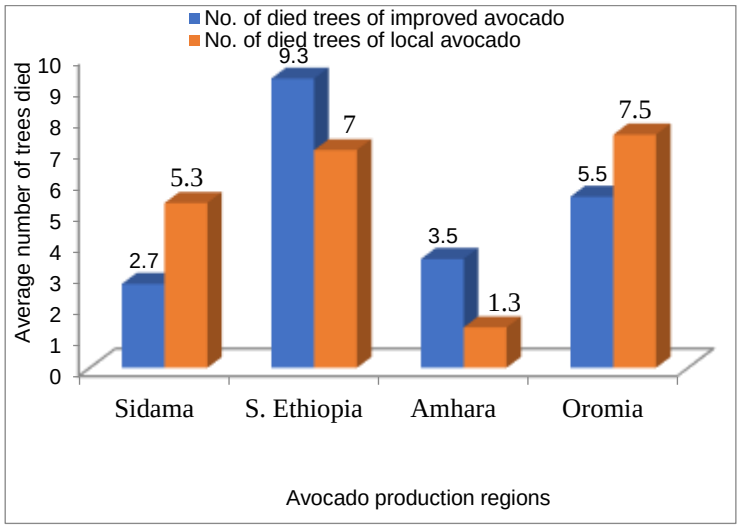


**Figure 2**: Comparison of avocado tree death and die-back

This implies that disease management in avocado fruit production is not given attention (Edeo *et al*., 2024; Demelash and Getachew, 2015; Berhanu, 2013; Woyessa and Berhanu, 2010) and unless avocado disease is well managed, there will be high-risk of losing the large number areas in every region and urgent diseases control management practices should be designed. Dying trees of commercial avocado varieties such as Hass trees are shown in Figure 3. The tree dies/ declines mainly due to disease and other various stresses that require a detail investigation and appropriate scientific management solutions.

Currently, avocado growers in South-Western Ethiopia including Oromia regions face problem of tree death, which needs to be managed properly before it progresses to all avocado cluster areas in all regional states of Ethiopia. Thus, avocado development initiatives should give priority attention to this disease and other problems that contribute to low fruit yield and quality, further integrated root rot management practices should give attention including use of clonal root rot tolerant avocado rootstock variety. Large number of tree death indicates absence of

scientific field management in avocado farming, thus strong follow up of all avocado orchards and plantations is required with further identification of other problems and finding immediate solutions for each problem in Ethiopia.

**Figure 3**: Drying commercial avocado trees (Hass variety)

Among the key constraints of avocado production, Berhanu, (2013) reported that avocado root rot (*Phytophthora cinnamomi* R.) incidence was high, 95% of avocado trees were infected in Manaa, Goma and Seka Chokorsa districts of Jimma Zone which demonstrated that nearly the entire production areas were suffering from avocado root rot. The assessment further signified severities of 25, 18 and 16% of *P. cinnamomi* in Manna, Seka Chokorsa and Goma districts, respectively. Thus, decline of avocado trees was detected in all the study areas. Mohamed *et al*. (2009) reported that established avocado plots in Jimma Agricultural Research Center were entirely devastated by avocado root rot disease; and about 30% of surviving trees were drastically hampered by the fungus. Woyessa and Berhanu, (2010), and Zekarias, (2010) reported similar observations. Since then, there a control measure or any avocado root rot management method has not been developed; rather the disease has been distributed to new areas, districts and zones including the whole Jimma and Illu-Ababor areas.

Another recently emerged pest of avocado in Ethiopia is *Persea mite,* and it is becoming an aggressive pest of avocado in most parts of avocado growing areas of Ethiopia (Abiy *et al*., 2024). This insect attacks in particular Hass variety which is highly susceptible reported by many researchers (COLEAD, 2023). Some other registered commercial avocado varieties in Ethiopia such as Fuerte, Pinkerton and Ettinger are either tolerant or much less susceptible (COLEAD, 2023), showing that avocado industry development in Ethiopia should focus on these varieties.

**Avocado field management awareness and follow up trends of transplanted trees**

Once transplanted, avocado trees require proper field and canopy management practices; among these management practices, removal of sprouts from the rootstock shall start immediately after field transplanting; deflowering of scions will start soon;, staking of each tree with support for wind protection, framing central leader shoot, irrigation, nutrient applications, removal of water suckers, tillage, weeding, pruning, fencing and protecting from animal damage and other managements are required for matured avocado trees (Table 7).

**Table 7:** Avocado field management awareness and follow up trends after transplanting

| Field management practices | Frequency | Per cent |
|---|---|---|
| Aware of mulching for improving the cultivation of avocado (1=Yes) | 240 | 89.6 |
| Aware of weeding for improving the cultivation of avocado (1=Yes) | 258 | 96.3 |
| Aware of pruning for improving the cultivation of avocado (1=Yes) | 172 | 64.2 |
| Mulching of avocado trees/ covering of roots now (1=Yes) | 214 | 79.9 |
| Mulch of avocado trees/ covering of roots last 10 years ago (1=Yes) | 110 | 41.0 |
| Did you do prune of avocado trees now (1=Yes) | 165 | 61.6 |
| Did you do prune of avocado trees 10 years ago (1=Yes) | 83 | 31.0 |
| Did you do tilling/ hoeing your avocado fields now (1=Yes) | 247 | 92.2 |
| Did you do tilling/hoeing your avocado fields 10 years ago (1=Yes) | 202 | 75.4 |

**Source:** Edossa *et al.*, (2024)

**Tillage and hoeing (*Kutkuato*)**

The respondents replied that recently 92.2% of the growers cultivated their avocado orchard regularly, whereas before 10 years 75.4% of the growers tended to cultivate the orchard (Table 7). It shows that growers are aware of the importance of avocado cultivation; this is usually associated with the application of fertilizer, compost and manure.

**Weeding**

Weeding is one of the oldest agronomic practices for crop production. The analysis of the results indicated that 96.3% of avocado growers continuously weeded their avocado fields (Table 7). Weeds in fruit farms do not shade the trees but compete for irrigation water and nutrients and become hosts for many diseases and insect pests. Still, potential ground cover crops in avocado farms have to be identified and promoted.

**Covering of avocado roots (mulching)**

The assessment results indicated that recently 79.4% of avocado growers covered all the exposed roots, while before ten years, it was only 41% of the growers covered the exposed roots (Table 7). Avocado trees require coverage of their roots while the roots are exposed (Figure 6). If the roots are damaged physically, avocado root rot fungus enters the root and plant system through the injuries or damages.

**Pruning and development of central leader**

The survey results showed that recently 61.6% of avocado growers interested to pruning their avocado trees, whereas before ten years, it was only 31.0% of the growers pruned their avocado trees (Table 7). Starting from the nursery, avocado seedlings require pruning and shaping the central leader. Once transplanted in the permanent field, avocado trees require development of central leader shoots and regular pruning which requires scientific knowledge. In addition, each avocado seedling requires shelter during the dry season from the strong sun and winds. Tree training starts in the nursery and follows immediately after transplanting with pruning every year after harvest.

**Estimated avocado fruit yield**

The survey study showed that avocado growers were obtaining an estimated total fruit yield of the highest 2.065 tons/ha in Oromia followed by 1.944 tons/ha in Amhara. Similarly, avocado growers in Sidama got an average of 1.765 tons/ha; and avocado growers in the South Ethiopia region obtained an estimated fruit yield of 1.583 tons/ha (Table 8). The reason for the small yield was that most avocado trees (cluster) were young and corresponding management practices were not provided. A maximum yield is expected to be attained after six years for grafted avocado trees; whereas around it will take 10 to 11 years after transplanting for local avocado types. However, in the presence of irrigation water, the entire local avocado trees should be replaced by commercial varieties.

**Estimated avocado productivity**

Based on the survey results of avocado yield per tree estimation, the yield per tree was converted to yield per ha at 277 tree population (6m

x 6m spacing, and 277 trees per ha). The study results showed that avocado fruits had good productivity all over the study areas during the study period. The highest estimated yield of 41.66 ton/ha was obtained in Amhara followed by 38.49 tons/ha in Oromia, and 35 tons/ha in South Ethiopia regions (Table 8). The early yield from young cluster trees at the age of four and five years was small and the maximum yield was attained at the age of six years and onwards. Thus, if all surviving trees are well managed, and dried trees are replaced immediately, one can ensure that avocado has excellent productivity in Ethiopia. The yield could be increased by increasing planting density to either 5m x 6m or 5m x 5m spacing (Table 8).

**Table 8:** Current estimated avocado productivity in the study areas with 277 trees per ha

| Region | Estimated mean avocado harvest (kg/tree) | Yield of 277 trees/ha (6mx6m) (kg/ha) | Estimated avocado yield (ton/ha) |
|---|---|---|---|
| Sidama | 130 | 36,010.00 | 36.01 |
| South Ethiopia | 126 | 34,990.20 | 34.99 |
| Amhara | 150 | 41,655.00 | 41.66 |
| Oromia | 135 | 37,489.50 | 37.49 |

**Source:** Edossa *et al.*, (2024), own estimation with 6m x 6m spacing (277 trees/ha)

With increasing density of commercial avocado to 5m x 6m spacing, 333.33 trees per hectare and with applying simple pruning, the yield of avocado fruits could be increased. The use of high density and ultra-high-density plantings are common practices in all avocado-producing regions of the world (Whiley *et al*., 2012). Accordingly, a denser plant population such as 5m x 5m spacing could be used as the branch diameter of both Hass and Ettinger trees is less than 5m and the canopy do not touch each other in the absence of pruning at Melkassa (Table 9) (Edossa *et al*., 2023). Thus, an estimated yield of 500 q/ha fresh avocado fruits could be harvested in the Amhara region at 5m x 6m planting density, while an estimated yield of 600 q/ha could be harvested at 5m*5m planting density under optimum field management practices (Table 9).

**Table 9**: Estimated avocado productivity in the study areas at different populations (5m x 6m and 5m x 5m spacing)

| Region | Mean avocado harvest (kg/tree) | Tree populations and estimated yield | | Tree populations and estimated yield | |
|---|---|---|---|---|---|
| | | 333.33 trees/ha (5mx6m) | Mean avocado yield (q/ha) | Population (5mx5m) | Mean avocado yield (ton/ha) |
| Sidama | 130 | 43329.00 | 433.29 | 52000.00 | 52.00 |
| South Ethiopia | 126 | 41995.80 | 419.95 | 50400.80 | 50.40 |
| Amhara | 150 | 49995.00 | 499.95 | 60000.00 | 60.00 |
| Oromia | 135 | 44995.50 | 449.95 | 54000.50 | 54.00 |

**Source:** Edossa *et al.*, (2024)

**Major constraints for avocado production in Ethiopia**

The survey study found that among the key problems of avocado production were a) lack of irrigation facilities and irrigation water, b) limited knowledge and skill in avocado management, c) high input price, d) flowers and fruits abortion and e) lack of true type seedlings (poor quality). Mestawet *et al*., (2022) and Terheggen, (2019) have also reported that smallholder avocado growers in Lemo Woreda, Hadiya Zone, and Central Ethiopia have no proper grafting knowledge, have no proper seedling management knowledge, poor plant management and no idea how to manage flowers and berry falls.

**Lack of irrigation facilities and shortages of irrigation water**

The study found that 75.2% of avocado growers in the Sidama Region replied lack of irrigation facilities and shortages of irrigation water, this was followed by 67.4% of avocado growers in Wolaita faced lack of irrigation facilities and shortages of irrigation water. An average of 57.4% of avocado growers in Oromia also faced irrigation facilities and shortages of irrigation water. Avocado growers in Amhara region have highest irrigation water access whereas avocado growers in Sidama and S. Ethiopia (Wolaita) regions have very low irrigation water access and facilities. Similar reports have been made by Mestawet *et al*., (2022) in Lemo Woreda, Hadiya Zone, Central Ethiopia, where almost all avocado growers HH have no nearby irrigation water accesses, unsuccessfully to source underground water and remote water source. It was observed during the survey that young avocado seedlings are suffering from moisture stress in many places in the Wolaita area and until the rain comes and there is no probability that these grafted avocado seedlings get irrigation water. In addition, bearing Hass avocado trees in the Wolaita area are not getting irrigation water. These results low seedling survival and low productivity of avocado trees.

Bearing avocado trees in almost all areas are facing moisture stress and are not getting irrigation water during the dry season, even where irrigation water is available farmers are reluctant to irrigate avocado fruits and give priority to other vegetable crops. As a result, trees become very weak, bearing very few fruits non-productive, fruits with very small yield and all fruits are under size. Many farmers have bad conception that compost and mulch would satisfy and replace irrigation water in the Sidama, Wolaita, Jimma, and other South Western parts of Ethiopia. Depending on the rainfall patterns of particular avocado growing areas such as Sidama, Wolaita and other areas of the country either supplementary or full irrigation must be arranged and provided for avocado orchard and plantations immediately after transplanting. It seems that campaigns of annual avocado planting without irrigation arrangement will face quite large number of tree death.

It seems that local un-grafted avocado trees are less stressed during the long dry season as compared to commercial varieties such as Hass and Ettinger in Sidama and Wolaita areas. The extent of moisture stress on commercial avocado varieties and local types requires further investigation. Export fruit size cannot be obtained from moisture-stressed commercial avocado varieties cultivated under rainfed without supplementary irrigation.

**Limited knowledge and skill on avocado management**

The survey assessment conducted found that there are poor avocado transplanting techniques and following transplanting followed by poor management. Sample avocado grower from Sidama, (78.2%); Wolaita, (62.8%); Amhara, (72.9%); and Oromia, (90.2%) replied that they have limited knowledge and skill on avocado management practices. Many thousands of seedlings are died every year due to poor pit preparation, transplanting and lack of after transplant care. There are reports indicating millions of grafted avocado seedlings are planted through campaigns every year, in many Zones of Oromia, Amhara and South Ethiopia. In many zones of Oromia, farmers who planted avocado seedlings by cluster stated that thousands of the seedlings have died

since seedlings were planted without preparing proper pits, basins, irrigation water and protection from domestic and wild animals.

In many places, seedling supply and pit preparation are done by campaign and many of the seedlings failed to survive. Even if the seedlings are survived, the farmers do not know the subsequent management. Linking avocado planting with the campaign, sense of urgency and green legacy did not contribute to the subsequent survival of avocado seedlings.

**Flower and fruit abortion**

The survey assessment found that avocado growers faced the key problem of flower and fruit abortion. Among the growers, farmers from Oromia, (27.9%); Wolaita, (30.2%); Sidama, (19%); and Amhara, with (10.2%) faced the same problem. Low flowers and fruit abortions of avocado fruits in Amhara region is due to availability of irrigation water and accessibility of irrigation facility whereas high percentage of flower and fruits abortions in Oromia, South Ethiopia (Wolaita) and Sidama region is due to un-availability of irrigation water and un-availability of irrigation facility in the regions implying development of irrigation facility and structures should be given attention.

Avocado flowers and fruit abort due to various stress reasons, among the key abiotic factors, moisture stress, lack of pollination, nutrient stress and disorders, and insufficient tree reserve foods can be mentioned (Salazar-García *et a*l., 2012). Unless avocado trees are well managed throughout the lifetime, flowers and fruits abortions are common. The provision of optimum irrigation and nutrients minimizes flower and fruit abortions. Some heavy stress would cause a carryover effect where a heavy yield in one year causes minimum yield during the subsequent years.

The seedlings have poor growth status, with no labels, and are not sure for sure from free from diseases and insects. Farmers received these seedlings without their interest and awareness. A previous study found that there is low-quality avocado seedling transplanting system in the southern part of Ethiopia (Mestawet *et al*., 2022). When grafted avocado seedlings were not transplanted within less than a year to the permanent field, and when they stayed in the nursery for more years the whole root system of the seedlings had twisted roots). These seedlings should not be supplied to the farmers because though transplanted the survival rate is minimal and the performance of the tree is not guaranteed**.**

**Institutional problems**

There is a lack of a peak industry body representing avocado farmers in Ethiopia working primarily to increase demand and overall avocado profit for avocado growers. In addition, there is no peak organization which is working with farmers, packhouse, exporters, importers and retailers both in Ethiopia and in the export markets.

There is no supportive relationship between producers and facilitating organizations. There should be a forum of support relationship between fruit producers and fruit development facilitating organizations such as local governments, business service providers, research institutes, universities and non-government service organizations that reinforce the quality, efficiency and sustainability aspects of the value chain. All actors involved in the avocado value chain development work independently; there is no horizontal and vertical networking and communications among them in contributing to problem-solving engagements in the avocado industry development.

**Lack of avocado grower–industry-exporters platform**

Production of best quality avocado fruits with global market requirements requires continuous discussions of all actors involved in the avocado value and supply chains. All actors would contribute towards the high quality and productivity of the avocado commodity. A regular improvement of the fruit's quality requires regular backward and forward discussions with the producers, packhouse operators, exporters and development leaders and supporters. In order to improve the quality of avocado fruits along the value chain, Ethiopian Horticulture Producers and Exporters Association (EHPEA) has prepared a number of guidelines that shall be implemented for export purposes and for the provision of a high-quality fruits for domestic markets **(**EHPEA, 2014a; EHPEA. 2014b; EHPEA. 2014c; EHPEA. 2014d; EHPEA, 2014e; EHPEA, 2014f; EHPEA. 2014g)**.** However, there are no problem-solving forums with stakeholder discussions inclusive of growers, packhouse operators, exporters and consumers in Ethiopia. In addition, there are no forums, platforms or guidelines that link actors along the value chains for the production and marketing of high-quality products. As a result, there is a lack of technical competencies in field production practices, harvesting operations, packaging, and further postharvest management practices until the avocado fruits reach final retailers and consumers. Working towards alleviations of these problems would lay foundation for the success of the Ethiopian Avocado Industry Development.

## CONCLUSION AND RECOMMENDATIONS

The study found that smallholder farmers were not managing their avocado plots in a uniform manner that improves fruit yields and qualities. There is no standard operating field management procedure applied in smallholder avocado production. Each grower applied different management practices that would produce low yields, and even the yield and quality of commercial varieties were not as expected, probably because of poor field management practices. Avocado was harvested year-round from different parts of Ethiopia. However, avocado fields were poorly managed and the cultivation of a large portion of local avocado types implied that there is still a long way to replace the local types with commercial varieties. The study found that the current avocado value chain development stage in the country varies among study areas (regional states) implying that there should be different approaches in every state that requires further studies.

Most problems in avocado production in Ethiopia arose from non-professionalism and unethical guidance of the farmers and actors along the value chains on proper nursery seedling preparation, site selection, pit preparation and continuous field management practices. First, the producer has to take the responsibility of a better operation of his cultivation in order to obtain a product of the desired quality that is able to compete in the international markets. District experts, development agents, farmers, harvesters, aggregators, transporters and store warehouses were the key players where unethical practices were involved. Beyond field transplanting, field management in avocado orchard (plantation) is overlooked and there is a lack of responsive actions in developing optimum irrigation water requirements, nutrient and pest management practices leading to low productivity and fruits quality. Therefore, proper extension support is required to enable smallholder producers to adopt improved production techniques encompassing proper spacing, tree training and pruning, soil amendments, growing several trees together for successful pollination, integrated pest management and improved harvesting. All avocado development stakeholders and avocado partners should work together towards improved management practices for sustainable yield, quality and lifespan of avocado orchards and plantations. It is necessary to use innovative orchard and plantation management practices that make Ethiopian avocado competitors across the globe. Thus it is crucial for avocado development planning, policy formulation and promoting of the industry development. Furthermore, it is important to design and formulate means and ways to facilitate the transformation of the existing commercial avocado production in Ethiopia.

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