



GROWTH AND YIELD PERFORMANCE OF AVOCADO (*PERSEA AMERICANA*) FRUIT TREE VARIETIES AT MIDLAND AGROECOLOGY OF GUJI ZONE, SOUTHERN ETHIOPIA

Aschalew Emire*, Sintayo Demise and Temesgen Giri

Oromia Agricultural Research Institute, Bore Agricultural Research Center, Guji zone, Southern Ethiopia

Corresponding author E-mail: aschu1511@gmail.com

ABSTRACT

The study was conducted at Adola Rede District, Guji Zone, in Southern Ethiopia. The objective of this study was to identify the best adaptable and high yielding Avocado (*Persea americana*) fruit tree varieties for Midland Agroecology of Guji Zone. Seedlings of grafted Avocado fruit tree varieties were laid out in randomized complete block design (RCBD) with three replications. A plot size of 10m x 6m was used for each Avocado fruit tree varieties. A plot consisted of two rows of grafted Avocado seedlings. On each row three grafted Avocado seedlings were planted and each plots had six grafted Avocado trees. Based on the objective of this study, vegetative growth parameters, yield and yield components data were collected during the study time. The results of this study revealed that, in terms of Vegetative growth parameters significant differences (at $P < 0.05$) was observed among avocado varieties. In terms of survival rate, the highest survival rate was recorded from Bacon and the least one was Ettinger. The recorded stem thickness data showed that Fuerte variety was significantly higher (at $P < 0.05$) than the others. The tree height data recorded revealed that the maximum and minimum tree heights were observed in Fuerte and Nabal varieties respectively. Moreover, there was a significance ($P < 0.05$) difference in canopy spread among the avocado varieties was observed. Pinkerton had larger canopy spread (4.627m) and least canopy spread was recorded on variety Nabal (1.287m). Avocado fruit length, fruit width, and fruit weight was significantly ($P < 0.05$) different among the varieties. The highest fruit length was recorded from Pinkerton (7.212cm) and the lowest value was found in Bacon (5.833cm). In terms of fruit width, the highest was obtained from Bacon (8.333cm) and the least one was recorded from Hass variety (6.033cm). The largest Fruit weight was obtained from Fuerte (0.285kg) and lowest fruit weight was recorded from Hass (0.111kg) avocado. The finding of this study revealed that the average number of fruits per tree of the six improved avocado varieties was varied statistically. Hass avocado produced a significant maximum number of fruits per tree (382) and Pinkerton variety produced the minimum number of fruits per tree (131). In terms of yield per plot, the maximum fruit yield per plot was obtained from Fuerte (140 kg) and the lower number of yield per plot (110.367kg) was recorded from Ettinger. The recorded total fruit yield per hectare of Fuerte variety was significantly higher than the other varieties. The maximum fruit yield per hectare was obtained from Fuerte (14,372 kg/ha) and the minimum was obtained from Pinkerton (12,262kg/ha). Therefore, Fuerte, Bacon and Hass Avocado fruit tree varieties were recommended for Avocado Producers at Midland Agroecology of Guji Zone and for similar agroecologies.

Keywords: Avocado, Fruit tree, Growth, Performance, Variety and Yield

1. INTRODUCTION

Avocado (*Persea americana*.) is an evergreen, subtropical fruit species is a native tree of Central American countries, the northern coast of South America and the West Indies. It has been grown on five continents and widely distributed to more than 50 countries around the world, which mainly includes sub-tropical and tropical areas such as sub-Saharan Africa. (Zentmyer, 1987; Knight, 2002). Avocado (*Persea americana*) is a polymorphic tree species that originated in a broad geographical region stretching from the Pacific coast of Central America through Guatemala to the eastern and central highlands of Mexico. Three distinct and separate sub-species now termed the Guatemalan, Mexican and West Indian or Antillean races have been selected over millennia (Popenoe, 1920; Knight, 2002).

Ethiopia is one of the top five Avocado (*Persea americana*) producers in sub-Saharan Africa. Avocado was first introduced to Ethiopia around 1938 by private orchardists in Hirna (Eastern Highlands of Ethiopia) and Wondo-genet (Southern Highlands of Ethiopia). Gradually, it has been distributed to different agroecologic conditions where the crop could be adapted (Edossa 1997; Woyessa and Berhanu 2010; Megersa and Alemu 2013). Despite its long history since introduction and the diverse agro-ecologic conditions of Ethiopia, its distribution is still limited to few areas of the country (CSA 2014). The avocado industry in Ethiopia is in its infancy and has not yet utilized the immense potential of this crop. Annual avocado production in Ethiopia is 25,633.16 tons. Avocado is now produced by 1,149,074.00 farmers country wide who collectively farm more than 8938.24 ha of land (Yilma, 2009; CSA, 2013).

In Ethiopia, major Avocado (*Persea americana*) producing areas include Sidama and Wolayita areas in the South, Jimma and Mizan areas in southwestern and Hararge area in eastern region of the country (Megersa and Alemu 2013; CSA 2014). In Midland Agroclimatic Districts of Guji Zone, Southern Ethiopia, communities of the area mainly grown Avocado trees around their homesteads, as an integral component of coffee which is used as a shade tree and in combination with other crops.

Study results conducted by Woyesa Garedew (2010) in Mana Districts, Jimma Zone indicated that even though Avocado (*Persea americana*) has economically and socially play a significant role its production is confronted by a number of constraints such as Degeneration of fruits, Disease problem and production practice is poorly supported by scientific agronomic practice. As well, in midland agroecology of Guji Zone, production of Avocado fruit tree is mainly hindered by insufficient number of avocado fruit trees per Ha, lack of adaptable, high yielding and better quality Avocado varieties. So far, available information on the Growth and Yield Performance of Improved Avocado (*Persea americana*) fruit tree varieties for Midland Districts of Guji zone is not generated. Thus, introduction of adaptable improved Avocado fruit tree varieties can be one of the strategies to increase production of Avocado at the study District. Therefore, this study was conducted to identify the best productive and adaptable Avocado fruit tree Varieties for Mid land Districts of Guji Zone.

2. MATERIALS AND METHODS

2.1. Description of the study area

The trial was conducted at Adola Rede District, Guji zone, Oromia Region, in Southern part of Ethiopia, at a distance of 475 km from Addis Abeba, the capital City of Ethiopia.

Astronomically, the absolute location of the District is between 5°44'10" - 6°12'38" North latitude and 38°45'10" -39°12'37" East longitude (Figure 1). Adola Rede District is characterized by three agro-climatic zones namely humid, sub humid and dry arid zones. The mean annual maximum and minimum temperature of the study District is 23 and 16°C, respectively. The rainfall pattern of the District is bimodal for lowlands and midland areas and mono-modal for high land parts. The major soil of Adola Rede District is Nitisols and orthcacosols and it is dominantly brown soil. Moreover, the study area has an elevation ranging from 1500 m above sea level in the southern part of the District. Whereas, in the north-western part of the District, it has an elevation greater than 2000 m above sea level. The farmers of the study District produce both in autumn and spring seasons. The traditional farming system of the study District is characterized by cultivation of major crops such as Teff, Bread wheat, Food Barley and Maize, Haricot bean and Sweet potato. Farmers of the study District also engaged in the production of coffee as means of livelihood.

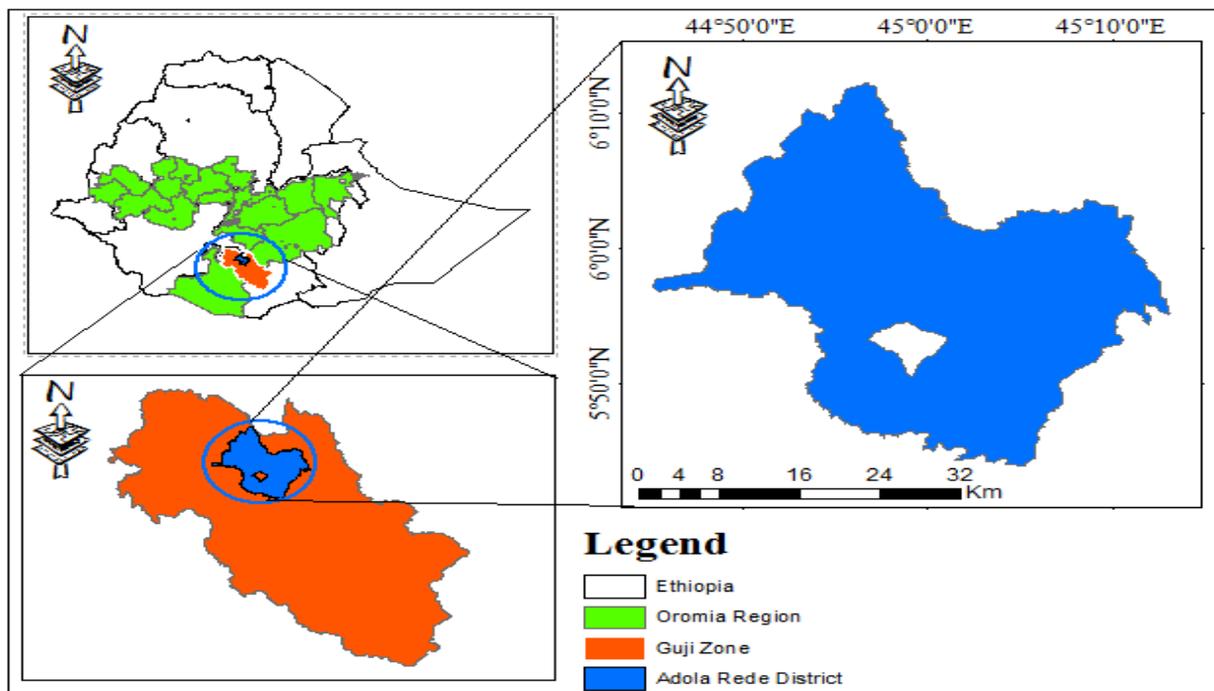


Figure 1. A map showing the study site

2.2. Source of Avocado Fruit Tree Varieties and Experimental Design

Seedlings of six grafted improved Avocado (*Persea americana*) fruit tree varieties, namely Ettinger, Bacon, Nabal, Fuerte, Hass and Pinkerton were used as experimental material and they were obtained from Melkasa Agricultural Research Center. The appropriate types of grafted seedlings were planted in a well-prepared hole with a depth, diameter and width of 50, 50 and 50 cm, respectively. The trial was arranged in randomized complete block design (RCBD) with three replications. A plot size of 10m x 6m was used for each Avocado fruit tree varieties. A plot consisted of two rows of grafted Avocado seedlings. On each row three grafted Avocado seedlings were planted and each plots had six grafted Avocado trees. Distance between the Avocado trees in the same row was 4m and distance between rows in the same plot and distance between blocks was 4m and 1.5m respectively.

2.3. Field Management

All field management practices such as manure, mulching, watering supply, Weeding, and pest and disease control were performed as necessary.

2.4. Data Collection

2.4.1. Growth parameters

Tree height (m): was considered by measuring the height of the largest scaffold branch from the ground level

Canopy spread: was calculated by mean measurements of the spreading of branches from North to South and From East to West.

Survival percentage: Number of wilted or dead seedlings from each Avocado fruit tree varieties was counted and recorded. Then at the end of the study period (using total number of dead seedlings) survival percentage was calculated.

2.4.2. Yield and yield components

Total Yields: were calculated in hectare base from the yield obtained from the plot measured by using the standard sensitive balance.

Fruit number per Tree: Was taken by counting all the fruits per tree and then make the average by dividing the number of trees per plot.

Average fruit weight (g): Was done by taking about 20 fruits randomly from each tree and make the average of them.

2.5. Data Analysis

The analysis was performed by using Statistical Analysis System (SAS version 9). Vegetative and yield recorded from each selected Avocado(*Persea americana*) fruit tree varieties were subjected to analysis of variance and Least Significance Differences (LSD) tests to enable comparison of the Avocado varieties.

3. RESULTS AND DISCUSSION

3.1. Vegetative Growth Parameters

3.1.1. Survival Rate and Stem thickness of Avocado Fruit Tree varieties

The results of analysis (ANOVA) revealed that in terms of survival rate and stem thickness growth parameters, significant differences ($P < 0.05$) were observed among six avocado fruit tree varieties. Survival rate of Avocado varieties (*Persea americana*) under the present investigation showed that Bacon Avocado variety was the highest(93.97%) followed by Fuerte(93.00%), Nabal(86.03%), Pinkerton(84.23%), Hass (83.13%), while survival rate of Ettinger(76.20%) was the lowest(Figure 2). As the finding of this study revealed that, the recorded stem thickness of avocado varieties ranged from 6.576 cm (Fuerte) to 5.120cm (Hass) with average of 5.912cm stem thickness. From all Avocado varieties used on this study by stem thickness Fuerte avocado

variety was significantly higher (at $P < 0.05$) than Bacon, Ettinger, Nabal and Hass avocado varieties. While statistically significance differences (at $P < 0.05$) was not observed between Fuerte and Pinkerton, and among Bacon and Ettinger improved avocado varieties (Table 1).

3.1.2. Tree Height and Canopy Spread of Avocado Fruit Tree Varieties

The analysis of variance indicated that there was significant difference ($P < 0.05$) in tree height was observed among the avocado varieties. The tree height of avocado varieties showed that, Fuerte and Pinkerton varieties were significantly higher (at $P < 0.05$) than the others avocado varieties (Table 1) However, Hass avocado variety had statistically similar plant height performance with Nabal Variety. As the finding of this study showed that, the variety Fuerte had higher growth in height (3.30m) and Nabal avocado variety showed less growth in height which is 2.257m (Table 1). Therefore, recorded mean height of Fuerte avocado variety was higher than the others variety. The finding of this study supported with previous finding which was indicated that taller plants are more productive than shorter trees due to light interception favored by taller plant (Day *et al.*, 1999).

The result of this study revealed that there was a significant difference ($P < 0.05$) in canopy spread among the avocado varieties over the growing years was observed. However, statistical difference was not observed between Nabal and Bacon avocado varieties (Table 1). In general, during growing years Pinkerton avocado variety had larger canopy spread (4.627m). While the least canopy spread was recorded on variety Nabal (1.287m). In support of this study, previous Study results showed that, tree vigor, is expressed by different parameters like plant height and canopy spread per volume, affected the photosynthetic rate and productivity and hence ultimately affected the economic yield (Almeida *et al.*, 2016).

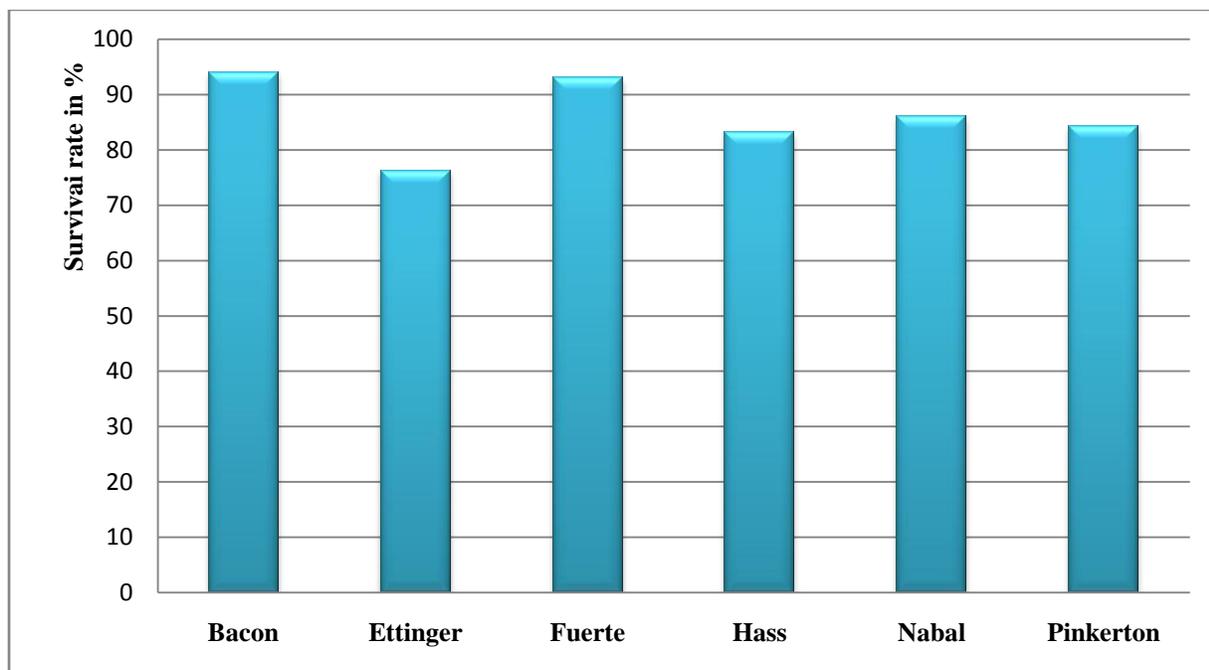


Figure 2. Survival rate of Avocado Fruit Tree Varieties

Table 1. Analyzed Growth parameters results on Performance of Avocado Fruit Tree Varieties at Adola Rede District, Guji Zone, Southern Ethiopia

Treatment	Vegetative Growth Parameters			
	Survival rate (%)	Tree Height (m)	Stem Thickness(cm)	Canopy Spread(m)
Bacon	93.97 ^a	2.523 ^b	6.113 ^{bc}	1.397 ^e
Ettinger	76.20 ^f	2.400 ^c	5.893 ^c	4.340 ^b
Fuerte	93.00 ^b	3.30 ^a	6.576 ^a	4.127 ^c
Hass	83.13 ^e	2.333 ^{de}	5.120 ^e	1.523 ^d
Nabal	86.03 ^c	2.256 ^e	5.450 ^d	1.287 ^e
Pinkerton	84.23 ^d	3.253 ^a	6.317 ^{ab}	4.627 ^a
Mean	86.094	2.677	5.912	2.883
CV (%)	0.411	2.242	2.507	2.816
LSD(5%)	0.263	0.106	0.264	0.144

*Means in columns with the same letters are not significantly different at ($P < 0.05$)

*Means in columns with the different letters are significantly different at ($P < 0.05$)

3.2. Yield and Yield Components

3.2.1. Fruit length, Fruit width and Fruit weight of Avocado Fruit Tree Varieties

The combined Analysis of variance (ANOVA) showed that fruit length was highly variable among the avocado varieties studied; the highest fruit length was recorded from varieties Pinkerton (7.212 cm) and the lowest value was found in Bacon which is 5.833cm (Table 2). From all avocado varieties, in terms of fruit length Pinkerton was significantly higher ($P < 0.05$) than Bacon, Nabal and Hass improved avocado varieties. Whereas, among the others avocado varieties statistically significance differences were not observed. As the finding of present investigation revealed that in terms fruit width, the highest was obtained from Bacon variety (8.333cm) and the least one was recorded from Hass avocado variety (6.033 cm) (Table 2). In contrary with this study finding, in Turkey maximum fruit length 13.9 cm from Pinkerton avocado variety and the minimum fruit length 9.1 cm recorded found in Hass avocado variety and greatest fruit width 8.1 cm was recorded from Reed avocado variety (Suleyman Bayram *et al.*, 2012).

Table 2. Analyzed yield and yield components results on Performance of Avocado Fruit Tree Varieties at Adola Rede District, Guji Zone, Southern Ethiopia

Treatment	Yield and Yield Components Parameters					
	Fruit Length (cm)	Fruit Width(cm)	Fruit Weight(kg)	Fruit number/Tree	Yield/Plot (kg)	Yield/Hectare (kg)
Bacon	5.833 ^b	8.333 ^a	0.245 ^b	210 ^c	117.933 ^c	13,165 ^b
Ettinger	6.312 ^{ab}	6.433 ^{ab}	0.225 ^b	169 ^e	110.367 ^d	12,532 ^d
Fuerte	6.931 ^{ab}	6.400 ^{ab}	0.285 ^a	285 ^b	140.767 ^a	14,372 ^a
Hass	5.521 ^b	6.033 ^c	0.111 ^c	382 ^a	116.433 ^c	12,862 ^c
Nabal	5.532 ^b	6.233 ^{ab}	0.232 ^b	186 ^d	120.033 ^c	13,338 ^d
Pinkerton	7.212 ^a	7.821 ^{ab}	0.231 ^b	131 ^f	130.467 ^b	12,262 ^d
Mean	6.223	6.771	0.221	227	122.666	13,088
LCD (5%)	2.636	2.541	0.121	9.46	4.242	5587
CV (%)	15.32	13.23	12.4	2.33	1.726	9.377

*Means in columns with the same letters are not significantly different at ($P < 0.05$)

*Means in columns with the different letters are significantly different at ($P < 0.05$)

From the results of this study, the highest individual mean fruit weight was recorded from the Varieties 'Fuerte' (0.285kg) and 'Bacon' (0.245kg) respectively and the lowest mean fruit weight was obtained from 'Hass' (0.1110 kg) (Table 2). Whereas, among others avocado varieties such as Bacon, Ettinger, Nabal and Pinkerton their fruit weights were not significantly different. In contrary to this study finding, in Ghana and Turkey obtained mean avocado fruit weight ranged from 0.66kg to 0.78kg and 0.3kg to 0.663 kg respectively (Suleyman Bayram *et al.*, 2012 ; G.O.Nkansah *et al.*, 2011). However, the finding of this study is relatively similar with research findings carried out in California on Selection and evaluation of improved varieties and root stocks of avocado and the maximum obtained average fruit weight was 271.6 gm (Marylu Arpaia, 2006).

3.2.2. Number of Fruits/Tree, Yield/Plot and Yield/ Hectare of Avocado Varieties

The result revealed that the average number of fruits per tree of the six improved avocado (*Persea americana*) varieties was varied statistically during the study time. As it is indicated in Table 2, from all avocado varieties used on this study, Hass avocado produced a significant higher number of fruits per tree (382) and Pinkerton produced the least number of fruits per tree (131). The finding of this study is relatively similar with research findings conducted in Ghana on Avocado Germplasm conservation and improvement. On their study results indicated that the obtained maximum and minimum number of fruits per plant was ranged from 5 to 240 (G.O.Nkansah *et al.*, 2011).

In terms of yield per plot, the mean maximum fruit yield per plot was obtained from Fuerte avocado variety (140.767kg). While from Ettinger avocado variety lower number of yield per plot (110.367kg) was recorded. However, the recorded mean yield per plot of three avocado varieties such as Nabal, Hass and Bacon did not showed significant difference. The analysis revealed that

total fruit yield per hectare of the evaluated avocado varieties showed statistically significant difference (at $P < 0.05$). Therefore, recorded total fruit yield per hectare of Fuerte avocado variety was significantly higher than the others varieties. The maximum fruit yield per hectare was obtained from Fuerte (14,372 kg/ha) and the minimum fruit yield was obtained from Pinkerton avocado variety (12,262 kg/ha). The result agrees with the finding of Smith (2006) which was indicated that the yield varies greatly with cultivar, age of tree, location, weather and other condition. The level of yield per hectare obtained also depends on cultivars, effective pollination and crop husbandry practices (Edosa, 1997; Linda, 2006).

4. CONCLUSION AND RECOMMENDATION

Ethiopia has suitable growth conditions that support optimal cultivation of many fruit trees in general and avocado in particular. However, a small proportion of this potential is used. Avocado cultivation in Ethiopia is characterized by insufficient number of trees per Ha, disease problem, lack of adaptable high yielding and better quality avocado varieties and production practice is poorly supported by scientific agronomic practice. To solve this problem, growth performance evaluation of six improved grafted Avocado varieties was conducted at Midland Agroecology of Guji Zone, Southern Ethiopia. Based on the findings of this study in terms of vegetative growth parameters like (survival rate, stem thickness, tree height and canopy spread) statistically significance differences was observed among the avocado varieties. The highest survival rate was recorded from Bacon (93.97%) and the least one was Ettinger (76.2%). In terms of tree height and canopy spread between avocado varieties significance variation was observed. The maximum and minimum tree heights were recorded from Fuerte (3.30m) and Nabal (2.25m) varieties respectively. While in terms of canopy spread, variety Pinkerton was observed to have larger canopy spread and the least canopy spread was recorded on variety Nabal.

According to this study, in terms of yield and yield components parameters significance differences was observed among the avocado varieties. The highest fruit length 7.212 cm was recorded from Pinkerton avocado variety and the lowest fruit width (8.333cm) was found in Bacon avocado variety. The average number of fruits per tree of the six improved avocado varieties was varied statistically. Hass and Fuerte avocado varieties were found outstanding produced a significant higher number of fruits per tree respectively. On the other hand, Pinkerton avocado variety produced the least number of fruits per tree. Moreover, the maximum fruit yield per plot was obtained from Fuerte variety (140.767kg/plot) and the lower number of yield per plot (110.367kg/plot) was recorded from Ettinger variety. As compared to others avocado varieties, the recorded total fruit yield per hectare of Fuerte variety was significantly higher. The maximum fruit yield per hectare was obtained from Fuerte (14,372kg/ha), Nabal (13,338kg/ha) and Hass (12,862 kg/ha) respectively and the minimum yield per hectare was obtained from Pinkerton (12,262 kg/ha). Therefore, Fuerte, Nabal and Hass Avocado Fruit Tree varieties were recommended for production at Midland Agroecology of Guji Zone and similar agro-ecologies.

ACKNOWLEDGEMENTS

We would like to thanks Oromia Agricultural Research Institute (OARI) for the financial support and Bore Agricultural Research Center (BOARC) for provision of the necessary facilities for research work. We also express our sincere appreciation to the Melkasa Agricultural Research Center for provision of seedlings of improved grafted avocado varieties for the study. In addition, we would like to express our gratitude to the staff of Agroforestry Research Team of

Bore Agricultural Research Center for their continuous follow-up of the experiment and data collection.

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