AVOCADO GERMPLASM CONSERVATION AND IMPROVEMENT IN GHANA

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INTRODUCTION

Ghana, Gateway to Africa lies in the center of the West African coast. It shares 2,093 km of land borders with three French-speaking nations, Burkina Faso (548 km) to the north, Côte d'Ivoire (668 km) to the west, and Togo (877 km) to the east. To the south are the Gulf of Guinea and the Atlantic Ocean. With a total area of 238,533 square kilometers, Ghana is about the size of the United Kingdom. Its southernmost coast at Cape Three Points is 4° 30' north of the equator. From here, the country extends inland for some 670 kilometers to about 11° north. The distance across the widest part, between longitude 1° 12' east and longitude 3° 15' west, measures about 560 kilometers. The Greenwich Meridian, which passes through London, also traverses the eastern part of Ghana at Tema.

The climate of Ghana is tropical, but temperatures vary with season and elevation. The country has a bimodal rainfall regime typified by a tropical rainforest. Except in the north, two rainy seasons occur, from April to July and from September to November. In the north the rainy season begins in April and lasts until September. Annual rainfall ranges from about 1,100 mm in the north to about 2,100 mm in the southeast. The harmattan, a dry desert wind, blows from the northeast from December to March, lowering the humidity and creating hot days and cool nights in the north. In the south the effects of the harmattan are felt in January. In most areas the highest temperatures occur in March, the lowest in August.

Avocado (*Persea americana* Mill) is a very important crop in Ghana and is one of the future promising export crops. The crop is widespread in the forest regions of Ghana. In Ghana, there is still no certainty and consent among historians and scientists on the period of time in which this fruit species was introduced in the country. However, it is believed that it was first introduced into the country during pre-colonial times by missionaries. The first recorded planting of avocado was at Aburi (near Accra) in 1870, with peasant production being recognized in 1907 (Anon, 1961). Improved commercial cultivars, mostly West Indian and West Indian x Guatemalan hybrids (including the cultivars Booth 7, Booth 8, Fuchsia, Lula, Monroe, Trapp, Choquette, Collinson, and Waldin), were introduced into the country later by the Plant Protection and Quarantine unit of U.S. Department of Agriculture–Animal and Plant Health Inspection Services and U.S. Agency for International Development (USAID). In the 1960s, 'Duke', 'Ettinger', and 'Fuerte', from the National Germplasm Repository (NGR) in Miami, FL, were among the latest cultivars to be introduced into the country (Acheampong *et. al*. 2008). However, all or most of these mother plants cannot be identified or located. Thus the problem of identification of races and cultivars and their crosses is compounded because since the original introductions were made, nearly all subsequent plantings have been made from seed sources and not from grafted materials.

Presently, there is few well thought-out orchard production of avocadoes in the country. Almost Ghana's entire avocado is grown by smallholders. Fruits are obtained from backyard plantings and volunteer crops scattered in cocoa and other farms in most parts of the country with the exception of the Northern and Upper Regions where the crop is not found. Avocado fruits of different shapes, sizes and colours can be seen displayed for sale all year round when travelling along the main road networks in the avocado producing regions, an indication of a large gene pool in the country.
Commercial avocado plantations are not available and there is no known certified avocado nurseries to supply the growers with grafted material except materials that are supplied by the Forest and Horticultural Crops Research Centre-Kade of the University of Ghana (Nkansah unpublished).

Available literature on research reveals that few studies have been carried out on avocado especially in terms of genetic conservation and improvement. Studies on genetic characterization using microsatellite markers revealed that most of the lines belong to the West Indian race (Acheampong *et*

al, 2008). The authors, however, were of the view that further studies using advanced form of markers to differentiate some Guatemalan hybrids and that of the West Indian race should be carried out. Again they intimated that they used a small sample of materials for the studies and recommended that increasing the avocado gene pool is imperative by new introductions of all the three races; West Indian, Mexican and Guatamalan to improve the Ghanaian avocado industry.

Attention must therefore be given to expanding the genetic base and selecting lines that meet export specifications. This calls for further exploration and collection of materials from the vast avocado genepool that still exists. The current collections being done has began the process of securing the genes that may be used in the future for avocado crop improvement. There is a tremendous amount of research that still needs to be conducted on avocado in Ghana and the time is now.
The objectives of these studies are to; 1) collect both local and leading world avocado varieties and establish them in a museum, 2) conserve, characterise and select desirable genotypes 3) multiply selected genotypes by vegetative propagation and release to farmers and 4) in addition use detailed trait characteristics of genotypes in the museum for varietal improvement and other agronomic purposes.

Materials and Methods

Survey and collection of avocado accessions

Field visits (Map) were made to several towns in the Ashanti, Brong Ahafo, Western and Eastern regions to collect avocado accessions and map plant positions. One hundred and ten (110) local landraces were collected from these areas and five (5) world leading varieties were obtained from South Africa. These materials have been established in germplasm museums at the University of Ghana Forest and Horticultural Crops Research Centre (FOHCREC), Kade in the Eastern Region of Ghana. The five varieties obtained from South Africa are 'Hass', 'Fuerte', 'Ryan', 'Ettinger' and 'Nabal'

Evaluation in Experimental farms

The first accessions, mainly local ones (110) were planted in 2006, The second planting comprising five (5) varieties obtained from South Africa plus nine selected local accessions from Experiment Farm 1 were planted in 2010. All establishments were done at FOHCREC, Kade.
The University of Ghana Forest and Horticultural Crops research centre at Kade is in the forest zone and is 114m above sea level on latitude 6^{o}.1573'N and longitude 0^{o}.9153'W. The dominant soil is Haplic Acrisol (FAO/UNESCO, 1990; Nkansah *et al*, 2007). The annual rainfall amount ranges between 1300-1700mm, and the distribution is bi-modal with two peaks around June-July and September – October. Temperature ranges between 25-38^{o}C (Ofosu-Budu, 2005).

Parameters Measured

Morphological characterization (leaf, tree and fruit) for fingerprinting of individual accession was done using the International Plant Genetic Resource Institute (IPGRI, 1995) Descriptors for Avocado (*Persea* spp.). The leaf characters measured included, leaf shape, colour and leaf margin. Tree characters determined were shape and trunk surface while fruit characters taken included fruit shape, fruit habit, fruit apex shape, ridges on fruit, pedicel position on fruit, gloss of skin. Fruit yield including fruit number per plant and fruit weight per plant were determined. Physiological characters like photosynthetic rate, transpiration rate, stomatal conduce, water use efficiency could not be measured due to lack of equipment.

Analysis

Data were subjected to analysis using a computer software..

Results

Morphological characterization

Evaluation of leaf characteristics

The results in Figure 1 indicate that five (5) leaf shapes were observed in the accessions, roundish (32%), lanceolate (28%), obovate (5%), oval (3%) and oblong-lanceolate (32%). Figure 2 shows the distribution of leaf colour at green, dark green and light green in the population. The percentages of distribution are 48, 43 and 10% for green, dark green and light green respectively. In Figure 3, two leaf margins were observed in the accessions, undulate (47%) and entire (53%). Figure 4 also indicate that two leaf base shapes were observed in the population, acute (72%) and obtuse (28%).

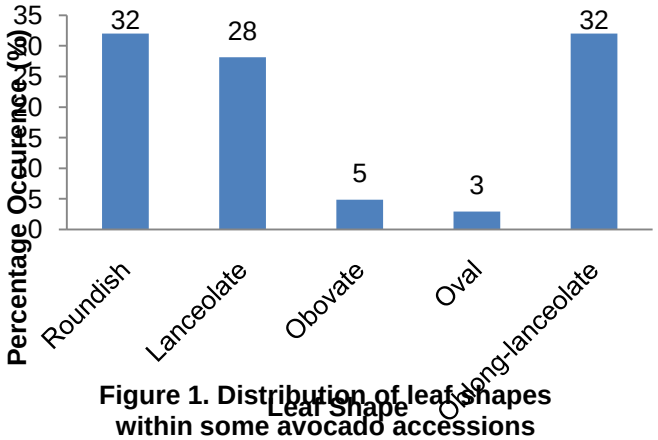

Figure 1. Distribution of leaf shapes within some avocado accessions

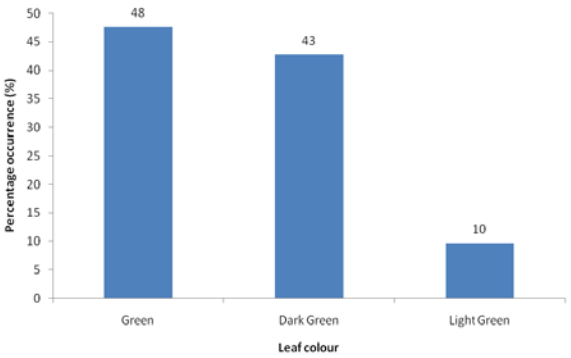

Figure 2. Distribution of leaf colour in some accessions

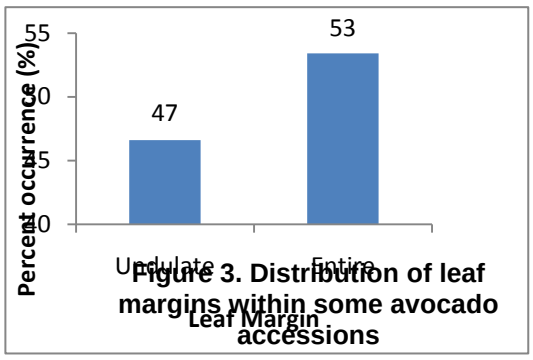

Figure 3. Distribution of leaf margins within some avocado accessions

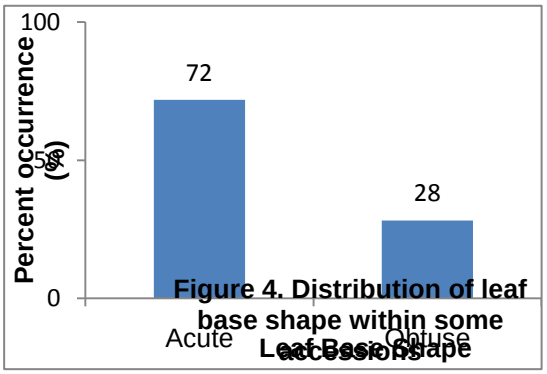

Figure 4. Distribution of leaf base shape within some accessions

Evaluation of fruit Characteristics

Seven (7) fruit shapes were present in the accessions, obovate (32%), narrowly obovate (18%), pyriform (18%), rhomboidal (18%), high spheroid (8%), spheroid (5%) and clavate (2%) (Figure 5).

In terms of fruit habit, two types of fruits were observed among the population, clusters (83%) and single (17%) (Figure 6). The data also showed that four (4) fruit apex shapes were found in the accessions. These are flattened (38%), rounded (27%), slightly depressed (27%) and deeply depressed (8%) (Figure 7).

Figure 8 shows that ridges on fruits were in four (4) categories, absent (74%), present (3%), partial (21%) and entire (2%).

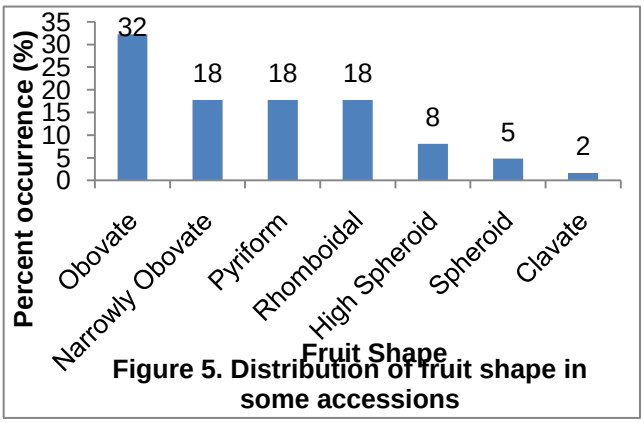

Figure 5. Distribution of fruit shape in some accessions

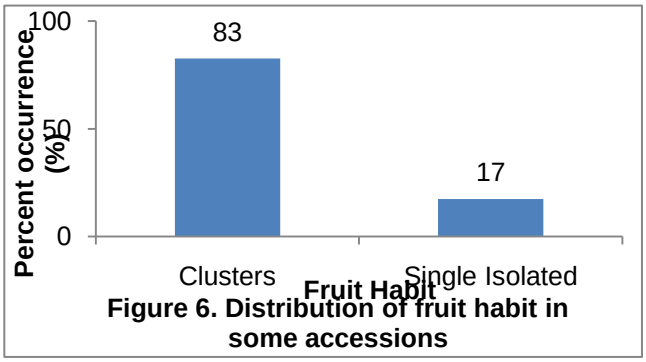

Figure 6. Distribution of fruit habit in some accessions

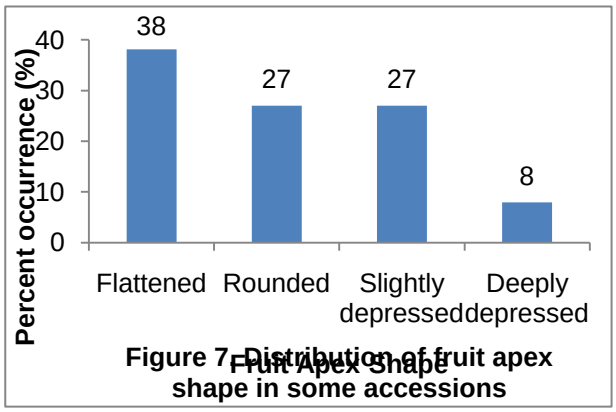

Figure 7. Distribution of fruit apex shape in some accessions

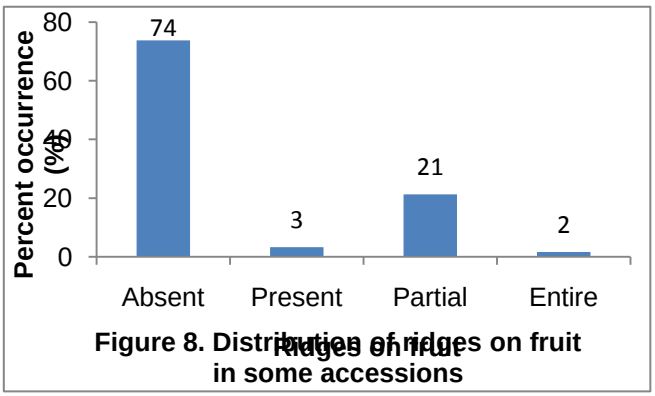

Figure 8. Distribution of ridges on fruit in some accessions

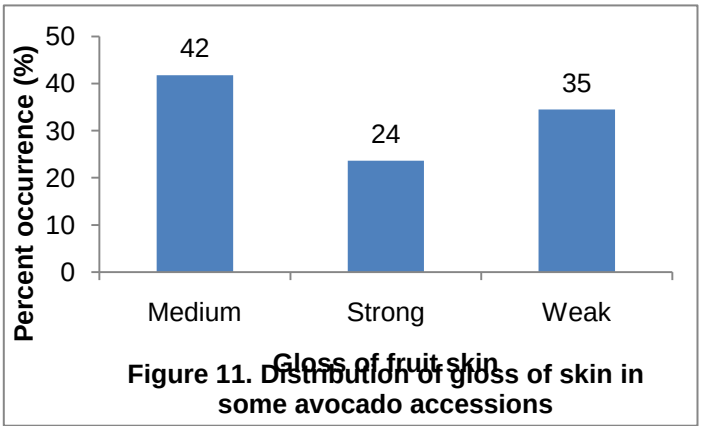

Figure 11. Distribution of gloss of skin in some avocado accessions

Evaluation of Tree Characteristics

Figure 9 shows the distribution of tree shape within the accessions studied. It ranged from 5.9% to 27.5%. Seven tree shaped were observed. These are circular (27.5%), semi-circular (8.8%), obovate (15.7%), columner (20.6%), pyramidal (9.8%), semi-elliptic (5.9%) and rectangular (11.8%). In terms of tree branching pattern, the distribution was either extensive (35%) or intensive (65%) (Figure 10).

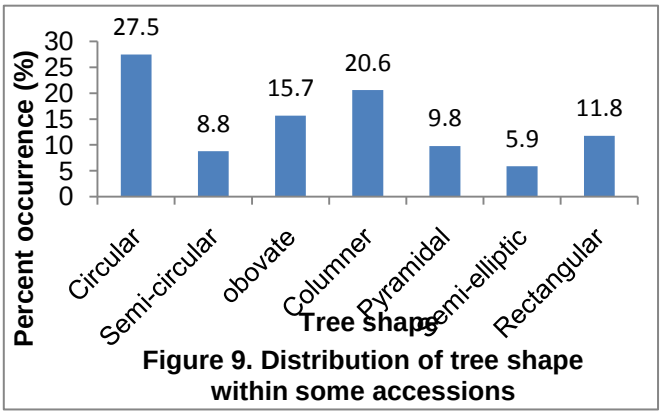

Figure 9. Distribution of tree shape within some accessions

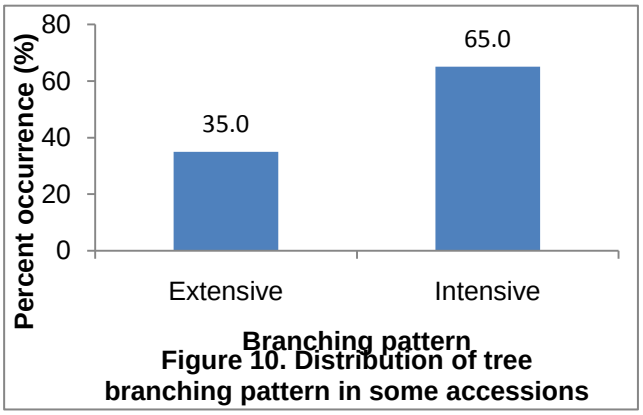

Figure 10. Distribution of tree branching pattern in some accessions

Evaluation of yield characteristics

There were marked differences in fruit number and weight per plant as well as the yield in tonnes (Table 1). The number of fruits per plant ranged from 5 to 240 while fruit weight per plant ranged from 0.66kg to 78.6kg per plant. Yield (t/ha) also ranged from 0.28 – 15.72 t/ha. **(**

Table 1. Yield performance of some accessions 6 years after transplanting

Accession No.	Fruit number (no./plant)	Fruit weight (wt/plant)	Yield (t/ha)	Accession No.	Fruit number (no./plant)	Fruit weight (wt/plant)	Yield (t/ha)
1	16	1196.00	1.20	53	149	6883.80	6.88
2	2	300.00	0.30	54	40	2728.00	2.73
3	9	654.00	0.65	55	58	4013.60	4.01
4	8	462.00	0.46	56	176	14044.80	14.04
5	4	440.00	0.44	57	15	849.00	0.85
6	4	300.00	0.30	58	217	10514.00	10.51
7	42	2520.00	2.52	69	55	3619.00	3.62
8	60	2500.00	2.50	60	58	3132.00	3.13
9	8	700.00	0.70	61	25	1955.00	1.96
10	12.7	8859.00	8.86	62	15.75	5000.00	5.00
11	56	3432.00	3.43	63	13.65	4620.00	4.62
12	31	1662.00	1.66	64	15.8	5600.00	5.60
13	78	5094.00	5.09	65	15.5	5360.00	5.36
14	10	582.00	0.58	66	14.48	4940.00	4.94
15	48	2254.00	2.25	67	15.5	5060.00	5.06
16	38	2564.00	2.56	68	15	5700.00	5.70
17	95	6032.00	6.03	69	15.5	4340.00	4.34
18	169	10080.00	10.08	70	92	4738.00	4.74
19	97	4308.00	4.31	71	30	5400.00	5.40
20	28	1366.00	1.37	72	30	1800.00	1.80
21	36	1740.00	1.74	73	46	3339.60	3.34
22	37	1650.00	1.65	74	51	5544.00	5.54
23	24	1588.00	1.59	75		0.00	0.00
24	25	1388.00	1.39	76	6	432.00	0.43
25	27	1294.00	1.29	77	50	2420.00	2.42
26	64	5120.00	5.12	78	15	957.00	0.96
27	135	9494.00	9.49	79	193	8858.70	8.86
28	60	4338.00	4.34	80	22	132.00	0.13
29	174	8430.00	8.43	81	22	1940.40	1.94
30	4	280.00	0.28	82	63	5798.00	5.80
31	184	9624.00	9.62	83	87	6246.60	6.25
32	27	2118.00	2.12	84	26	2199.60	2.20
33	65	5320.00	5.32	85	89	6016.40	6.02
34	43	3292.00	3.29	86	77	4689.30	4.69
35	32	2200.00	2.20	87	146	9767.40	9.77
36	182	8248.00	8.25	88	95	7790.00	7.79
37	51	2446.40	2.45	89	219	13884.60	13.88
38	31	1660.00	1.66	90	27	1722.60	1.72
39	7	400.00	0.40	91	21	1247.40	1.25
40	10	1052.00	1.05	92	104	7415.20	7.42
41	4	240.00	0.24	93	38	505.40	0.51
42	116	9521.20	9.52	94	20	1288.00	1.29
43	47	2276.00	2.28	95	215	15716.50	15.72
44	142	8970.00	8.97	96	82	4337.80	4.34
45	36	1992.00	1.99	97	7	443.80	0.44
46	65	3964.00	3.96	98	11	700.70	0.70
47	12	776.00	0.78	99	157	12198.90	12.20
48	12	782.00	0.78	100	12	1068.00	1.07
49	14	3534.00	3.53	101	60	3768.00	3.77
50	14.25	5066.00	5.07	102	107	6484.20	6.48
51	36	2022.00	2.02	103	14	795.20	0.80
52	178	9167.00	9.17				

Growth performance of commercial and local cultivars/accessions

Plant height was significantly highest in Ettinger (57.1 cm) while the least was recorded for NK 9 (34.0 cm) (Table 2). Leaf number per plant significantly differed among the commercial cultivrsa and local accessions (Table 2). Ettinger had the highest leaf number per plant (68.7) followed by NK 5(76.0) and the least was recorded by NK 9 (13.0). In terms of plant girth, again variations were observed and Ettinger had the highest (10.3 cm) while NK 9 had the least (5.2 cm).

A comparative analysis between the commercial cultivars from South Africa and the local accessions revealed that the commercial cultivars numerically performed better than the local in terms of growth (Table 3). Plant height, leaf number per plant and plant girth were 49.8cm 49.4 and 9.9cm for the commercial and 42.3cm, 41.0 and 8.4cm for the local respectively.

Table 2. Growth performance of some accessions after transplanting to the field after 2 years

Variety/Acc	**Plant Height (cm)**	**No. of Leaaves/plant**	**Plant girth (cm)**
Ettinger	57.1	68.7	10.3
Fuerte	50.4	39.3	9.2
Hass	54.0	50.9	10.2
Nabal	37.6	32.2	10.2
Ryan	50.2	56.1	9.7
NK1	41.5	44.0	10.3
NK 2	44.3	57.0	11.5
NK 3	36.0	38.6	9.7
NK 4	48.6	67.0	10.2
NK 5	56.2	76.0	8.9
NK 6	38.5	31.2	6.0
NK 7	42.0	20.5	6.5
NK 8	39.3	22.0	6.9
NK 9	34.0	13.0	5.2
LSD (5%)	2.02	2.69	1.06

Table 3. Comparative growth traits for commercial and local accessions transplanted in 2009

Cultivar/Accession	Plant height (cm)	Number of leaves (no./plant)	Plant girth (cm)
Commercial	49.8	49.4	9.9
Local	42.3	41	8.4

Discussion

The avocado germplasm were collected from four out of 8 avocado producing ecological zones of Ghana. These avocado accessions have developed traits adaptable to the peculiar environments in which they have evolved. The pattern of variation exhibited for various characters were substantially different. Variations in leaf shape may express the extent of leaf area hence seasonal integral of light interception which may be correlated with yield. Variations in accessions with respect to leaf colour may be significant in photosynthesis as dark green leaves tend to have high chlorophyll content which may be associated with high yields.

It was also observed that, there were distinct variations in fruit shape which ranged from obovate, pyriform, rhomboidal, spheroid and clavate. Fruit shapes like obovate and pyriform conform to that of commercial cultivars like Hass (obovate) and Fuerte (Pyriform) (Villiers, 2001). The distinct variation in fruit habit with respect to the clustering of fruits may be of yield significance. More fruit clusters per axil may be of good genetic material for breeding purposes. The twenty four percent (24%) pattern in the gloss of skin colour is significant as these materials may be used to breed cultivars that have waxy fruit skin surfaces.

Variations in tree shape were distinct with a higher percentage of the accessions being circular and the least semi-elliptic. In terms of branching pattern a higher percentage (65%) of the accessions was intensive while thirty five percent branched extensively.

Growth traits of the commercial varieties introduced from South Africa in terms of height, leaf number and stem girth did not differ substantially (Table 1). This may be attributed to the fact that the trees are now adapting to the environment and that they were transplanted about two years ago. However, some numerical differences were observed when compared to the local accessions. The commercial cultivars for now seem to be more vigorous than the local materials in the second farm.

Conclusions

The present study shows that considerable amount of genetic variability exits in the avocado species with respect to growth performance which offers scope for selection and breeding. This work gives a direction to effect further studies for genetic improvement and other agronomic and IPM trials. The implementation of this program of selection, introduction of commercial cultivars and propagation of avocado in Ghana which is being carried out by the Forest and Horticultural Crops Research Centre, Institute of Agricultural Research, is the first avocado Germplasm bank with promising plant material especially commercial cultivars obtained from South Africa.This museum will greatly accelerate the pace for avocado improvement by allowing screening for desirable fruit and tree characteristics.

Recommendations

It is recommended that more cultivars and other accessions should be collected to increase the genetic base. Collaboration is also needed for genetic, physiological and biochemical studies with industry and researchers worldwide to strengthen the industry in Ghana.

Acknowledgement

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