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THE SUITABILITY OF THE SOILS OF MANGOASE CO-OPERATIVE FARM FOR LARGE-SCALE CULTIVATION OF AVOCADO PEARS

by

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C O N T E N T S

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INTRODUCTION

General:

During mid-1961, a decision was made by the Mangoase Co-operative Society and the Co-operative Development Officer for the U.G.F.C. at Koforidua to establish avocado-pear farm near Mangoase. Clearing, followed shortly by planting of the pear seedlings, started in September 1961. Early in March 1962, a soil survey of the proposed area was requested and a small team of technical assistants headed by Mr. J.T. Ama, Senior Scientific Assistant was sent to the area immediately. The Senior Author was overall in charge of the survey. Field work was completed in mid-May, 1962.

Purpose of the Survey:

The main purpose of the soil survey was to determine the suitability of the proposed area for large scale cultivation of avocado pears.

Conduct and method of Survey:

The motor road between Mangoase and Korangsang was used as the main base line and the farm was located by chaining from Korangsang junction towards Mangoase to a distance of $1\frac{1}{2}$ miles (120 chains). A central base line was cut from the 60th chain point on the main base line on a bearing of 55^{o} Mag. From this line traverses were cut at 10 Gunther's-chain intervals and soils were investigated either by chiselling or augering at 5-chain intervals.

ENVIRONMENTAL CONDITIONS OF THE AREA

Location and extent (see Map 1)

The area lies approximately 1 mile west of Mangoase on the Mangoase-Suhum road and occupies that parcel of land lying north-east of the road stretching from the village of Metemano for a distance of $1\frac{1}{2}$ miles towards Suhum. The plot occupies an area of approximately $1\frac{1}{2}$ square miles which is equivalent to 1,240 acres.

Climate:

The area falls within the semi-deciduous rain forest belt of Ghana with a two-peak wet and dry seasons, respectively. The wet seasons extend from mid-March to mid-July and from the end of August to mid-November with the rest of the year generally hot and dry. The period between mid-July to the end of August is, however, relatively cool and cloudy in addition to the normal dryness.

There are no climatic data available for the area, but an evaluation of records from the surrounding towns of Koforidua and Suhum suggests that the area may receive an average annual rainfall of between 60 and 65 inches with average monthly humidity at 0900 and 1500 hours of 84 and 65 percent, respectively. Temperatures are expected to range between a mean maximum of 92.2°F in February and April and a mean minimum of 69.3°F in August.

Geology:

The area is underlain by Plutonic, igneous rocks of which granite predominates. The granite is generally coarse-grained with biotite forming the most important ferro-magnesium mineral and the feldspar mostly of the soda-lime type.

The general direction of most of the outcrops closely follows the general pattern of rock foliation. There is, therefore, the possibility of the granite being originally of a Birrimian nature. Pegmatite veins at right angles to the general direction of the rocks are common and sometimes consist of large crystals of microcline closely interwoven with similarly large crystals of quartz into a quartz-feldspar intergrowth. Mica books, embedded in a lit-par-lit formation are commonly associated with these coarse-grained pegmatites which sometimes take on porphyritic forms along the contacts.

Basic intrusions, probably younger than the granite, also occur. The most important of these occupies the north-eastern corner of the plot, running in a northerly direction. It is mostly coarse-grained greenstone with epidiorite filling the joint planes.

Close to the eastern boundary, along the 60th base line, occurs a greenstone dyke cutting the granite at 310° Mag. At the contact zone of these two intrustive rocks, occurs a material, gabbroic in character, which is sometimes as fine-grained as dolerite.

An amphibolite intrusion of minor importance (showing euhedral structure) occurs around the 30th peg, west of traverse 5, containing about 15% feldspar.

Relief and Drainage (see Map 1)

The area is predominantly gently undulating with the highest topography occurring on the northern section ranging from 400 to 350 feet above sea level towards the south. The uplands are rocky in places.

The main stream draining the area is the Dedewa which takes its source from the high land on the north-western corner. This stream is fed by numerous tributaries which mostly branch out in the low valleys occurring within the Southern portion. The most important of these tributaries are the Korangsang, Adentam, Onyinawusu and Aboabo.

Vegetation

The predominant vegetation is of the forest deciduous type of which Chlorophora exelsa and Antiaris africana are the indicator trees.

Forest of any appreciable size is rare at the moment; the little that remains must have been reserved during the late thirties probably for cocoa farm extensions. The greater part of the area is under thicket with oil palm featuring as the most important tree.

Three types of vegetation are recognised. They are: secondary forest; thicket (oil palm or Lantana) and forb-regrowth.

Secondary Forest

The little secondary forest that remains is well matured, with tall trees over 60ft high. It is open and penetrable, with ill-defined strata. It is more than 20 years old.

Floristic composition:- The most important are:

Trees:- Antiaris africana, Chlorophora excelsa, Triplochiton scleroxylon, Ficus capensis, Hymenostegia afzelii, Teclea grandifolia, Albizia adianthifolia, Cola gigantea var. glabrescens, Alstonia boonei, Sterculia tragacantha, Ricinodendrom africanum and Elaeis guineensis.

Shrubs:- Ochna barteri, Trichilia heudelotii, Macrolobium limba and occassional species of Baphia nitida, Mallotus oppositifolius and Griffonia simplicifolia.

Thicket

The thicket is well matured, about 20ft high, thorny and impenetrable but open where oil palm predominates.

Floristic composition:- The most important species are:

Trees and coppice shoots:- Blighia sapida, Antiaris africana, Cola gigantea var. glabrescens, Cola millenii, Terminalia ivorensis, Triplochiton scleroxylon, Ficus asperifolia, Sterculia tragacantha, Ficus capensis, Albizia zygia, Ceiba pentandra, Ricinodendrom africanam and Elaeis guineensis.

Shrubs:- Solanum torvum, Mallotus oppositifolius, Byrsocarpus coccineus, Althomia cordifolia, Cnestis ferruginea, Holaarhena wulfsbergii, Baphia nitida, Griffonia simplicifolia, Datura metel and Lantana salvifolia.

Herbs:- Paullinia pinnata, Smilax kraussiana and Commelina nudiflora.

Forb Regrowth

This type of vegetation is not more than five feet high. It may be found open in some cases but it is generally impenetrable on account of the thorny Lantana.

Floristic composition:- The most important species are:

Coppice shoots of: Lantana salvifolia, Albizia zygia, Ficus asperifolia, Dalbergiella wulfsbergii, Ceiba pentandra, Alstonia boonei, Holaarhena wulfsbergii, Deinbollia pinnata, Baphia nitida, Griffonia simplicifolia and Clerodendron capitatum.

Herbs:- Talinum triangulare, Cardiospermum halicacabum, Balsamina momordica, Wedelia africana, Smilax kraussiana and Tridax procumbens.

Land use

Formerly, cacao was the most important crop grown in the area. This crop is at present confined only to the upper half of the area, the rest having been destroyed by swollen shoot. Replanting has been carried out and the percentage of cocoa, both old and new, is about 15-20%.

Maize and cassava form the most important food crops being grown by the indigenous farmers.

The tapping of palm-wine for distillation purposes and the extraction of palm-oil are some of the occupations of the inhabitants of the surrounding villages.

So far, the oil palm has met with considerable success on most of the soil types within the area (see Fig. 2 in the appendix). It is recommended, therefore that should the pear industry fail, either as a result of economic set backs or other unforescen circumstances, an oil palm plantation should be substituted.

CLASSIFICATION OF THE SOILS

General:

Two systems of classification have been employed in describing the soils of Mangoase Co-operative farm. These are Taxonomic and Technical systems of soil classification. In the Taxonomic system the soils are classified on the basis of the operating soil forming processes as they are inferred from the morphology of the soil profile. In this report, the nature and properties of the parent materials, their drainage condition and position on the landscape are taken as the main criteria for classifying the soils.

In the Technical system, however, the classification is based on one or more characteristic feature(s) or property (ies) which is (are) important and of value for a particular objective. In this instance, the capability classification of the soils in terms of their suitability for the large scale cultivation of avocado pears is evaluated.

Taxonomic Classification of the Soils

The soils of Mangoase co-operative farm have been formed in course of time through the influence of climate, vegetation, relief and drainage on the prevailing geology. Relief and drainage seem to be the most variable and as such are mainly responsible for the several types of soils occurring.

On the uplands the soils are moderately shallow, red to brown, moderately well-drained, concretionary, sandy clays developed over biotite granite. These are classified as Sedentary Soils.

Along the piedmont slopes, usually where the slope is concave, occur deep to very deep, red to brown, moderately well to imperfectly drained, non concretionary clays developed in materials derived from the upland soils. These are classified as Piedmont Drifts and constitute the most important soils of the area because of their good physical condition. The red variant is usually associated with the red concretionary upland soils and occurs on slopes varying between 4 and 6%. The brown variant occurs lower down the slope below its red counterpart and may sometimes be found dove-tailed to the lower end of the brown concretionary soils. It is usually associated with slopes of 2 to 3%.

Along the lower slopes and on gradients varying between 1 and 2%, occur deep, imperfectly drained, pale-brown sandy clays or gritty sands. These have accumulated from hill-wash materials and are thus classified as Colluvial Soils.

Close to the main motor road and lying between the Dedewa and the Adentam streams occurs a flat lowland consisting of unsorted variety of soil phases. The first 2-3 feet of a typical profile is sandy in texture underlain (almost abruptly) by plastic alluvial clay. Probably this lowland area formed part of the original flood plain of the two streams which has since been raised due to rapid accumulation of materials from the uplands to form a dry bed. These have been grouped with the colluvial soils but are considered as Old Alluvial Soils.

In the broad valleys of the Dedewa stream, occur deep, poorly to very poorly drained and moderately heavy to heavy clays. These are classified as Alluvial Soils.

The various soil series are placed under the major groups as follows (see map 2):-

A. Sedentary soils (Upper and middle slopes)

1. Moderately shallow, moderately well-drained, red concretionary sandy clay - Bawjiase Series.

2. Moderately shallow, moderately well-drained, brown, concretionary sandy clay - Adawso series.

B. Piedmont Drifts (Piedmont slopes)

1. Deep to very deep, moderately well-drained, red, non-concretionary sandy clay - Korangsang series.

2. Deep, moderately to imperfectly drained, brown, non-concretionary sandy clay - Kukua series.

C. Colluvial soils (Lower slopes)

1. Deep, imperfectly drained, pale-brown, hill wash gritty sand - Nta series.

2. Deep, imperfectly to poorly drained, grey-brown old alluvial clay - Nta clayey variant.

D. Alluvial soils (Valley bottoms).

1. Deep, very poorly drained, grey mottled heavy clays - Densu series.

2. Deep, poorly drained, grey moderately heavy clays - Nyantina series.

Technical Classification of the soils (see Map 3).

This is in a form of a land capability classification based on the United States System but modified so as to accommodate the soils of Ghana as outlined by Obeng and Smith (3).

In brief, the classification groups the soils of Ghana into seven general capability classes based on their suitability for either mechanized and hand cultivation of arable crops or for pasture, tree crops and/or for woodland or wildlife purposes. Classes I to IV soils* are those considered suitable for both mechanized and/or hand cultivation of any crop which the climate of the area will allow. Class V and some Class VI soils are considered suitable for limited mechanization, but well suited for hand cultivation and/or bullock farming of arable crops as well as for pasture and tree crops. Class VII and some Class VI soils are considered unsuitable for any type of cultivation and are thus recommended for Forestry, wildlife protection or for water-shed purposes.

The soils of the Mangoase Co-operative farm fall within five of the seven general Capability Classes and sub classes. These are IIs**, IIIw, IVw, IVs and VIs.

Class IIs soils

These consist of deep to moderately deep, moderately well-drained, medium textured soils with moderate water holding capacity, moderate permeability and medium inherent fertility. They are subject to no more than slight erosion e.g. Korangsang and Kokua Series. Such soils are considered very suitable for the prolific production of any climatically adapted crop including Avocado pear, provided management practices conducive to the raising of the fertility level of the soils coupled with measures to counteract erosion are employed. Some of the practices recommended for such soils are mulching, manuring, addition of commercial fertilizers and contour ploughing.

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* In determining the type of class under which a soil is to be placed, the following characteristics are evaluated - Depth, drainage, texture, slope (topography), permeability, waterholding capacity and inherent fertility. The limitation of one or more of these characteristics to mechanized and hand cultivation becomes progressively greater from class I to class VII.

** The suffix 's' is a subclass designation referring to the fact that the predominant limitation involves shallowness, too light or too heavy textures etc. Other subclasses are 'c' referring to climatic limitation, 'w' and 'c' referring to limitations involving wetness and erosion, respectively.

Class IIIw Soils

These consist of deep to very deep, imperfectly to poorly drained, light to medium textured soils with low to moderate water holding capacity, high to low permeability and low inherent fertility. They may be subject to moderate erosion e.g. Nta Series and its clayey variant. Such soils are suitable for both mechanized and hand cultivation but are limited in the number of crops that can be grown on them. Avocado pears may be grown on IIIw soils but only moderate yields can be expected even if the fertility level of the soils is raised and drainage is controlled.

Class IVs Soils

These consist of moderately shallow, moderately well drained, medium textured soils with moderate water holding capacity, moderate permeability and medium inherent fertility. They are subject to moderate erosion e.g. Bawjiase and Adawso Series. Such soils are considered suitable for limited mechanization but well suited for hand cultivation of a wide variety of arable and tree crops including avocado pears. Sustained prolific crop production will be realized if the management practices recommended for class IIs soils are followed.

Class IVw Soils

These are deep, poorly to very poorly drained, moderately heavy to heavy textured soils with a high water-holding capacity, low permeability and medium inherent fertility. They are subject to no more than slight erosion e.g. Nyantina and Densu Series. Such soils are considered suitable for mechanized cultivation of some arable crops using heavy machinery and for the hand cultivation of some water loving tree crops. They are, however, considered unsuitable for the cultivation of Avocado pears due to their poorly drained condition.

Class VIs Soils

These are shallow, excessively well drained, rocky soils which are considered unsuitable for any type of cultivation. When cultivated, the soils may be permanently damaged by severe erosion. Such soils are encountered around the north-east section of the area, where greenstone intrusions occur. They are unsuitable for avocado pear cultivation and must be devoted to forestry purposes.

CONCLUSION AND RECOMMENDATIONS

The root system of the Avocado pear is not very intensive and it generally penetrates deeply into the soil. The tree is sensitive to waterlogging and poor aeration and according to Jacob and von Uexkull (2), oversaturation of the soil with water for a period of two days can cause irreparable damage to the tree. They state further that on badly drained soils, the avocado tree is short-lived and very liable to root-rot caused by Phythophthora cinnamoni. The tree is noted by Traub (5) to require large quantities of available nutrients because of its deep root system and its rapid growth condition. Jacob and von Uexkull (2) recommend a weakly acid to acid medium (pH 5.5 to 6.5) as the most favourable for good growth of the tree.

From the foregoing, it follows that the ideal soil for avocado pear is that which is deep to moderately deep, well to moderately well-drained, medium textured, moderately acid with a moderate water holding capacity, moderate permeability and either a high inherent fertility or with the capacity to utilize large quantities of added nutrients. On the Mangoase Co-operative farm, Korangsang and Kukua Series which fall within land capability subclass IIs are, therefore, considered the most ideal soils for the large scale cultivation of avocado pear. Moderate to high production of the crop can be obtained on capability subclass IVs land consisting of Bawjiase and Adawso series. If more land is required Class IIIw soils (Nta and its clayey variant) may be used but under strict management practices involving drainage and application of commercial fertilizers. Classes IVw and VIs land (Densu, Nyantina and the greenstone derived rocky soils) are considered unsuitable for the crop due to their respective waterlogged and shallow condition.

On the accompanying Land Capability map at the cover, the various land capability subclasses have been rated according to their suitability for the large scale cultivation of avocado pear. Subclass IIs land is considered good for the crop followed by IVs land rated as very fair and IIIw land as only fair. These three groups of soils constitute about three quarters of the area, approximately 930 acres. The rest of the area is made up of subclasses IVw and VIs soils which are considered unsuitable for the cultivation of avocado pear. Rice and oil palm can, however, be successfully grown on IVw soils and it is recommended that these crops be grown in the area in addition to avocado pear. Subclass VIs land is too shallow, too rocky and too poor to be cultivated and must, therefore, be left in its present vegetation state.

For continuous prolific production of avocado pear, Jacob and von Uexkull (2) recommended the application of the following rates of fertilizers:

When using straight fertilizers: lbs/acre

a) Young trees (up to 5 years)

N.........10-15 lbs = 50 - 250 lbs Sulphate of Ammonia (20%N)

P_2O_5......10-90 lbs = 100 - 500 lbs Superphosphate (18% P_2O_5)

K_2O.......10-50 lbs = 20 - 100 lbs Sulphate of potash (50%K_2O)

b) Old trees (over 5 years)

N........80-100 lbs = 400 - 800 lbs Sulphate of Ammonia

P_2O_5.....60-125 lbs = 350 - 700 lbs Superphosphate

K_2O.....100-150 lbs = 200 - 300 lbs Sulphate of Potash.

When using complete fertilizers: lbs/acre

a) Young trees:

200 - 1,000 lbs of a 5-10-5 fertilizer.

b) Old trees:

750 - 1,500 lbs of a 12-8-12 fertilizer.

In addition to N:P:K, several of the trace elements have also been found to be essential to good growth of the plant. Magnesium in particular, according to Ruehle (4), may be as important as any of the major elements since the content in the avocado leaves indicates a considerable need of this nutrient. Other trace elements which may be needed are zinc, copper, manganese, boron and iron. Deficiencies of these trace elements according to Jacob and von Uexkull (2), are generally controlled in the usual way by foliage spraying.

Time of application of the required fertilizers varies mainly with the prevailing climate. Chandler (1) reports that the general practice in Florida (with almost similar climatic conditions as Ghana) is to fertilize 5 or 6 times per year, 3 times with complete fertilizer including magnesium and between these with nitrogen only.

APPENDIX

General profile description of the various soil series.

A. Upland Sedentary Soils.

1. Bawjiase series

This is a moderately shallow, moderately well-drained, upland soil confined mostly to the summits and the upper slopes of gentle undulating topography. The texture is moderately heavy and slight to moderate erosion is likely to occur when the soil is intensely cultivated.

The first 9 inches of the profile consist of dark brown to dark reddish brown humic light loam to light clay, weak, medium sub-angular blocky in structure, slightly firm and porous. This layer grades into a reddish brown to dark reddish brown sandy clay with similar structure but firm and porous with frequent to very frequent sub-angular quartz gravel and stones. Below this layer, about 20 inches from the topsoil, occurs a similar horizon, but with less concretions underlain by a reddish brown mottled yellow angular to sub-angular blocky light clay containing rare patches of decomposed granite. This parent material is usually hard, and porous. The pH is near neutral in the topsoil becoming acid with depth.

2. Adawso series

This is a drainage associate of Bawjiase series, occurring mostly on middle slopes.

The profile consists of about a foot of dark brown loamy sand to light loam which is slightly loose and porous with rare fine quartz gravel. This horizon grades into a brown, coarse light loam to light clay, weak medium sub-angular blocky in structure, firm and porous, with rare ironstone concretions, very frequent fine quartz gravel and occasional fine quartz stones. At a depth of 1½ feet from the surface of the soil, occurs a yellow-brown to strong brown, coarse light clay to clay with similar structure and consistency but containing rare to occasional fine sub-angular quartz gravel and stones. Rare ironstone concretions and manganese dioxide concretions may be present. Underlying this horizon, at a depth of about 30 inches, occurs a yellowish brown faintly mottled yellow sub-angular blocky sandy clay with frequent patches of decomposed granite and occasional rare fine quartz gravel and stones. This parent material is usually hard and porous. The pH trend is similar to Bawjiase series.

B. Piedmont Drift Soils

1. Korangsang Series

Korangsang series is a red, moderately deep, non concretionary soil. It is moderately well drained, generally moderately heavy in texture and occurs on ' upper slopes.

The first 10 inches of the profile consist of brown to reddish brown light loam which is loose and porous. This top layer overlies a reddish brown sandy clay, weak medium sub-angular blocky in structure and slightly hard and porous. Below this horizon, at a depth of about 18 inches, occurs a reddish brown to weak red sandy clay with similar structure and consistency grading at a depth of 30 inches into a weak red clay which may contain a stone-line underlain by a faintly mottled reddish brown and yellow decomposed granite below 48 inches. The profile is near-neutral in the topsoil becoming acid with depth.

2. Kukua series

Kukua series which is a drainage associate of Korangsang series occurs on middle slopes.

The top 9 inches of the profile consist of a dark greyish brown to dark brown, porous light loam, which may contain rare fine quartz gravel, overlying at a depth of 18 inches, a layer of dark brown to greyish brown sandy clay which is weak medium sub-angular blocky in structure and slightly loose and porous with rare fine quartz gravel. Below this layer occurs a dark brown to brown faintly mottled yellow sandy clay with similar structure and consistency but containing rare soft manganese dioxide concretions and occasional patches of decomposed granite. The reaction trend is similar to that of Korangsang series.

C. Lowland Colluvial Soils

1. Nta Series

This is a deep, imperfectly drained, gritty sand developed in hill-wash material. It occurs on lower slopes in association with either Bawjiase and Adawso series or with Korangsang and Kukua series.

The first 9 inches of the topsoil consist of a very dark greyish brown to greyish brown loamy sand to light loam which is loose and porous. This overlies a pale brown to yellow-brown loamy sand to light loam with rare to occasional fine quartz gravel which may extend to 30 inches. Below this horizon, occurs a yellowish brown to pale brown mottled yellow and brown sandy clay containing occasional soft manganese dioxide concretions underlain at a depth of 48 inches by a layer of decomposed granite. The profile is usually moderately acid in the topsoil becoming more acid with depth.

2. Nta series, clayey variant.

Along the old valley flats occur soils almost similar in profile to Nta series but with clayey lower horizons. Such soils are usually imperfectly to poorly drained.

A typical profile consists of about 30 inches of dark grey to dark greyish brown loamy sand to sandy light loam which is loose and porous and may contain rare fine quartz gravel and soft manganese dioxide concretions. Underlying this horizon is a greyish brown to brown mottled white and yellow plastic clay containing occasional fine quartz gravel and rare soft manganese concretions. The soil is usually acid throughout its profile.

D. Valley Bottom Alluvial Soils

1. Densu series.

This soil occurs along the flat stream beds. It is distinctly mottled, very poorly drained, deep, heavy and impermeable.

The first 9 inches of the profile consists of a very dark grey to grey silty to sandy clay, moderate medium sub-angular blocky in structure and very firm and plastic. This overlies a dark greyish brown sandy clay with similar structure but hard, sticky and more plastic grading at a depth of 19 inches into a greyish brown mottled grey and yellow, slightly compact, sticky and plastic clay. Below this horizon, at a depth of about 32 inches, occurs a greyish brown to yellowish brown mottled light grey and yellow, compact, sticky and plastic, sub-angular blocky clay containing occasional soft ironstone and manganese dioxide concretions, sometimes grading into a similarly plastic clayey layer containing calcium carbonate concretions. The reaction of the profile is usually slightly acid in the top-soil becoming near-neutral to alkaline with depth.

2. Nyantina series

This soil occurs in the valley bottoms of the smaller streams and often grades into Densu series. It is deep, poorly drained and moderately heavy to heavy in texture.

The first foot of the profile consists of a dark-grey sandy loam to sandy clay, weak medium sub-angular blocky in structure and slightly loose and porous overlying a dark greyish brown to brown sandy clay with similar structure but very firm and porous and containing occasional minute pieces of feldspar, rare fine quartz gravel and soft manganese dioxide concretions.

At a depth of 2 feet, occurs a brown mottled yellow sub-angular blocky sandy clay containing rare fine quartz gravel and occasional pieces of feldspar. Underlying this horizon, is about a foot of brown, mottled yellow, grey, and orange-brown, compact sandy clay with similar structure and containing occasional soft manganese dioxide concretions, occasional fine quartz gravel, frequent pieces of minute feldspar and sometimes rare calcium carbonate concretions. The pH trend is similar to that of Densu series.

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FIGURE 1: The southwest section of the area showing the main sign board and partly-cleared land for replanting Avocado pears.

FIGURE 2: Healthy growth of oil palm on class IVw land.

FIGURE 3: A cutline of fairly healthy young avocado seedlings on class IIIw land.

FIGURE 4: Very healthy growth of Avocado pear on class IIs land. Notice the practice of grass mulching.