Banana
Production and Utilization in Ethiopia

Research Report No. 35

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**Background**

In Ethiopia there are two problems concerning water. During rainy seasons, the main problem is handling rain water. At times flooded rivers carry away the valuable fertile soil and water and even destroy crops, villages, etc. Right after the rainy season people start to cry for water. Harvesting water in the rainy season and using it for dry season domestic agriculture and industry purposes could solve these problems. With the expansion of irrigation, new crops that give high yield and quality products will be introduced. These crops, besides contributing to food self sufficiency in the country, bring foreign currency through export. But dependency on rainfall, monoculture or concentration on few cereal crops and rigid food habit of the people are three major problems in the present Ethiopian Agriculture.

Most Ethiopians rely on cereals as source of carbohydrate. As a result they are exposed to food deficit whenever there is shortage of rainfall. Increase in population and limited cultivable land are expected to aggravate the situation in the future. To solve this problem Ethiopia should produce diverse food, horticultural and vegetable crops and pulses to feed its people and export agricultural products.

The rigid food habit of the people is another reason for food shortage in the country. People suffer from food shortage while plenty of potential foods are available. This rigid food habit should give way to economical and nutritious food habits by continuously educating the people about food value, importance of balanced diet, production and utilization of essential foods etc. For the achievement of this goal, schools,
colleges, mass media, religious and other concerned government and non-government organizations should work together.

Introduction

Banana is one of the important fruit crops used both as staple and dessert. In some East and Central African countries for example, banana is a staple or co-stable food. As a result these communities, unlike the cereal producing ones, do not suffer from food shortage. Similarly, in southern and south-western Ethiopia, though population density is considerably high, people are not seriously affected by drought as those in northern and eastern Ethiopia mainly due to the use of 'enset' (a relative of banana), banana, roots and tubers.

Due to its relatively little land preparation, care, maintenance and a comparatively high yield per given area and time, banana is well suited to traditional agricultural system. Banana yield is not seriously affected by competition from intercrops. As a result, banana supplies both food and cash to producers throughout the year. In gardens it is common to grow a range of cultivars to avoid risk due to diseases or pests.

In Ethiopia, banana is the second major fruit crop produced next to citrus. The dessert type is a popular fruit crop among producers and consumers. The bulk of banana is produced in traditional agricultural system where gardens are small and intensively managed, immediately surrounding the homestead. Banana is produced throughout the country [2]
wherever there is adequate rainfall or irrigation opportunity. But although it has great potential as export commodity besides its use as a cheap source of carbohydrates, minerals and vitamins and as well as a shade tree for coffee plants in coffee producing regions, production is mainly meant for home consumption.

The other type of production is semi-intensive small scale production. At present the major suppliers of banana to major cities are southern and south-western Ethiopia, i.e., Arba Minch, Mizan Teferi, and Tepi. The bulk of the produce comes from scattered and disorganized peasant sectors.

The third type is large scale (commercial) production under irrigation geared mainly for large cities and for export. Commercial banana production was started in the Middle Awash Valley at Melka Sedi. At its peak, the plantation cover was more than 700 ha and it used to yield over 25 t ha⁻¹. At that time, the farm was well organized with the needed grading, treatment, packing, storage and transportation facilities. Besides supplying quality fruits to big cities, the farm was exporting substantial amount to Middle East, Europe and the neighboring countries. According to Yohannes Agonafer (1994), out of the total exports of fresh fruits and vegetables in 1974, banana alone had a share of nearly 50% in quantity and 43% in value. This figure dropped drastically in 1987. After land nationalization due to mismanagement, build-up of salinity and nematode incidence yield and quality of fruits declined substantially. As a result of this the export dwindled and the produce is now marketed locally. The attempt to establish a plantation at Gewane to eliminate this drawback was not successful. But, banana
plantation at Aware Melka is reasonably good. Both plantations are managed by the state.

The yield and quality of banana is poor both in peasant and state sectors. This is mainly due to failure to use appropriate technologies such as better varieties and improved/scientific practices in spacing, sucker management, fertilization, irrigation, disease and pest control, and time of harvest. In addition, a good portion of the produce is lost due to mishandling after harvest (harvesting, transportation and ripening).

'Enset' and banana are produced together in areas with altitude of 1800 m. As the altitude increases, 'enset' will be dominant. Banana dominates as the altitude decreases provided that there is adequate moisture. In gardens banana is produced with root and tuber crops, vegetables, pulses and cereals.

Research work on banana was started in early 1970s at major research centers. But, study on breeding, agronomy, crop protection, economics and utilization is not emphasized still. Cultivar development was the major research activity. From introduced and locally collected varieties, Dwarf Cavendish, Poyo, Giant Cavendish, and Ducasse Hybrid were recommended for production. Recently more clones were collected and obtained from abroad. Promising clones are identified and promoted to multi-location variety trial. Sucker management and fertilizer trials conducted in state farms indicated that low number of suckers per hill and potassium application have a positive impact on the yield and
quality of banana. Amount and frequency of irrigation was recommended for Werer area. Spacings for plant crop were suggested. Similarly, treatments against burrowing nematode were studied.

Generally, if proper attention is given to banana research and development, it will play an important role in the food-self-sufficiency program of the country.
The Banana Plant

Banana Genomes
Indonesia and South East Asia are considered as homelands of banana and centers of earliest domestication. Most bananas and plantains are triploid and are related to two wild diploids—Musa acuminate (AA) and Musa balbisiana (BB).

The triploid Musa acuminate (AAA) includes the most important banana types. It is generally sweet and relatively tolerant to diseases. Gross Michael, which is tall and big and produces attractive fruits, is in this group. Due to its susceptibility to Panama wilt this variety is not in production at present. Cavendish, on the other hand, is relatively short and produces smaller fruits compared with Gross Michael. Its resistance to Panama wilt makes it the most popular dessert banana type. There is great variation in plant height, fruit size, yield and response to growing hazard within the Cavendish group. East African cooking type is also in this group.

Hybrids of Musa acuminate (AA) and Musa balbisiana (BB), i.e., the AAB or ABB groups, generally contain a lot of starch and are not sweet even after ripening. These groups are sometimes referred to as plantain. They are harvested and cooked before or after ripening depending on the varieties. Some varieties of this group are tolerant to disease and drought.

The cooking and beer bananas are adapted to relatively high altitude and humid regions, whereas AAB and ABB types are produced in more arid regions due to their resistance to drought.

[6]
Concerning the introduction of banana to Ethiopia, no one knows for sure when it entered to the country. But, from the diversity of planting materials available in the country, one tends to believe that it is not a recent introduction.

Utilization and Nutritional Value
Bananas and plantains are produced mainly by developing countries in the tropics and sub-tropics. These crops are staple for millions of people in the world. Regions that produce and consume banana and plantain include East, Central and West Africa, Asia, The Pacific, Central and South America and West India.

The fruits are eaten raw as they ripe, they are served boiled, steamed, fried green or ripe. Fruits are processed to different products (juice, beer, figs, powder, flour, chips, flakes, jams, wine, gin, baking soda etc.). Male flower buds are eaten as vegetable in some parts of Asia. Post-harvest pseudostems are chopped and fed to animals, used as mulch and incorporated with soil and used as sources of organic matter. Leaves are used as rapping materials. Pseudostems and petioles are used for house thatching and rope making.

In Ethiopia all types (dessert, cooking and beer) are available in banana growing regions and all are consumed fresh. As a result cooking and beer types are considered poor quality dessert types. Besides its being the cheapest source of carbohydrate, ripe banana fruit is a good source of vitamins A, B, C and minerals, which other staple food crops such as cassava, potato and cereals are lacking.
Parts of the Banana Plant

Banana is a huge semi-perennial herbaceous plant consisting of corm, roots, pseudostem, leaves, inflorescence, stem and bunch (Fig. 1).

Figure 1. Parts of the Banana Plant
Corm
At the base of a banana plant, there is corm (rhizome or bulb) which is underground storage. It consists of a central bud which develops into a plant. The lateral buds on the corm may develop into suckers. The number of buds that develop into suckers depends on variety, developmental stage of the main plant, and cultural practices followed by producers. Corm produces a large number of roots from its lower part.

Roots
Adventitious roots are formed from the corm. Uptake of water and essential elements depends on the size, length and condition of roots. Roots are anchors to the plant. Banana roots do not penetrate deep but they spread laterally. Their length is severely affected by nematodes, diseases, insects and poor soil management. The bulk of the roots concentrate on the upper 30 cm soil.

Stems
At first the overlapping leaf sheathes form pseudostem. Later on, the true stem emerges from the corm through the pseudostem. At the end of the true stem inflorescence and the bunches are formed.

Leaves
A leaf consists of leaf sheath, petiole, midrib and leaf blade. The sheath is that part of the leaf that extends from the corm forming the pseudostem and terminated by petiole. Petiole is that part which links the sheath and the midrib. Midrib is the extension of the petiole that carries the leaf blades. In the life time one banana plant produces up to 70 leaves. At a time 10 to 15 leaves are found on a healthy plant. The number of
leaves and the rate at which they are produced depend on variety and growing conditions. The main function of leaves is to photosynthesise.

**Inflorescence**
After a certain period of vegetative growth, the terminal bud develops into true stem. At emergence from pseudostem, the true stem produces inflorescence at its tip. Inflorescence, in turn, develops into bunch, groups of female and male flowers being covered by bracts.

**Bunch**
The inflorescence develops into a bunch which comprises six to twelve hands, each of which can have about twelve fingers. Due to the sterile nature of domesticated banana, the female part develops into seedless fruits (fingers). The shape and size of bunches, hands and fingers depend on type, variety, environment and cultural practices followed.

**Potential for Banana Production**
Ethiopia lies entirely in the tropics where vast areas are suitable for banana growing. The optimum banana growing regions have an average annual temperature of 20°C and a well distributed annual rainfall of about 1000 mm. South and Southwest of Ethiopia which are hot and humid with adequate amount and distribution of rainfall produce banana under rainfed condition. These areas thrive well in mid and low altitudes. Still, areas with access of irrigation water (lakes, rivers and wells) in mid and low altitudes have potentials to produce banana successfully. However, high
yield and quality fruits are obtained in lower altitudes (Awash River Valley) with supplementary irrigation. Introduction of highland cultivars (cooking types) has a potential to extend the production area since there is a great variation among varieties in their reaction to temperature. But, when exposed to low temperature (less than 16°C), growth and development are negatively affected. Development is accelerated at higher temperatures—the optimal temperature being 26 to 27°C. For prior fruit setting, however, relatively lower temperatures are favorable.

Most soils are suitable for banana production. The problem with soil is maintaining fertility and productivity. Labor is not a problem since the majority of the population is involved in agriculture.

The local consumption and export potential to neighboring countries are reliable markets. According to the late Etfruit's general manager, export potential is not exploited properly due to lack of facilities such as efficient packing houses, packages, storage and transportation. What is really needed now is effective extension program to disseminate technologies that are developed in the country or adopted from other countries to users.

The Ethiopian Rift Valley is accessible both to ports and major cities and can produce banana for export and local supplies. Commercial large scale plantations are recommended in areas with altitude of 500 to 1000 m and having supplementary irrigation. With the improvement of road transport these days, Arba Minch, Tepi and Mizan Teferi have become major suppliers of banana to Addis Abeba and other local markets.
Individual producers need to be organized to get farm inputs and to sell their produces. Areas that are not easily accessible can produce all types of banana for local consumption to improve local diet.

Banana and 'enset' are friendly crops to environment and play important roles for sustainable agriculture in South and Southwest Ethiopia. They are used to prevent soil erosion on sloppy areas. Bananas' high yield and availability throughout the year encourage both producers and consumers.

**Propagation**

The banana plant is a large, herbaceous perennial. The cultivated banana and plantain fruits are formed parthenocarpically; that is, without the normal fertilization (pollination). Hence, they are propagated vegetatively.

**Varieties**

All sorts of varieties (dessert, cooking, brewing) are grown throughout Ethiopia. These materials are not studied well.

**Cavendishes**

This group is originally from China and includes most of the dessert cultivars (Dwarf Cavendish, Giant Cavendish and Poyo) produced in the commercial farms of the country. They are more resistant to wind damage and Panama diseases than Gross Michael.

*Dwarf Cavendish* Due to serious infection of burrowing nematode on observation trials, Dwarf Cavendish became out of use at Werer in the early 1970s. At Melka Sedi farm,
particularly in the cold growing season, its hands are closely spaced on the stalk which is difficult to sever a hand without damaging the fruits below. It is reported that the fruit has a greater tendency not to color under the cold conditions in November - February than Poyo and Giant Cavendish. It is the variety currently produced at Awara Melka state farm. Since it is found to be susceptible to burrowing nematodes, frost, and cigar-end rot, researchers advise extension workers and producers not to use it particularly in areas infected with nematodes.

*Poyo and Giant Cavendish* Poyo and Giant Cavendish are the varieties that are recommended for the production of dessert type. Both have desirable fruit shape and size, acceptable flavor and are relatively tolerant to burrowing nematodes. They have high acceptance both in local and export markets. Poyo is more robust, easily transportable, looks better in the market and has good acceptance by consumers compared with Dwarf Cavendish.

*Ducasse Hybrid (Pisang Awak or Kenya)*
Ducasse Hybrid gives higher yield than Poyo and Giant Cavendish in relatively cooler areas like Melkasa. The variety is tolerant to major growing hazards such as wind damage and frost. It gives some fruits in marginal areas with minimum inputs. Its fruits are small and they lack banana flavor. It is considered a low quality dessert banana and has low acceptance in markets. It is a banana cultivar grown in East African countries and is mainly used for brewery purpose.

From a six years' banana observation trial at Jima, Ducasse
Hybrid; Matoke; and Gititi are found to be relatively adaptable to the area. The two Cavendishes and Poyo fitted poorly there. There are many cultivars of both dessert and cooking type in pipeline which are superior in many aspects compared with the existing ones.

**Planting Materials**
Different parts of banana are used as planting materials. The kind of plant developed and its initial rate of growth depend, to a large extent, on the nutritional status of the planting materials (sucker, corm, 'bit' or eye) used and fertility of the soil.

**Suckers**
Suckers are rhizomes in which the central growing points are used as planting materials. There are three major types of suckers.

**Sword suckers** The sword suckers are formed from deeply seated buds with a broad attachment to the parent rhizome. They emerge at the soil surface as spear like structures with small, narrow leaves. Well developed sword suckers are good planting materials. They are followers that should be removed to avoid competition with mother rhizome. Sword suckers may either be planted whole-with pseudostem and roots attached, or the pseudostem may be cut just above the growing point, and the roots and outer layers are removed.

**Peepers** These are suckers which emerge just through the soil surface and are used as planting materials.

**Water suckers** Buds formed when the parent corm has
increased in size and undergone some maturation, tend to be more superficial and less vigorous. These buds are formed high upon the parent rhizome and they give rise to broadly laminated leaves soon after they appear above the ground. They are referred to as water suckers, are weak, and generally less desirable as planting materials.

**Corms or bits**

In this case the central growing point is removed leaving a side bud to produce a new plant. An eye on a corm develops into a sucker. Hence a portion of a corm is used as planting material. The newly growing bud depends entirely on the stored food in the corm or piece of corm. For initial development the size is very important (about 1.5 kg/ piece). Large rhizomes can be splitted in to several bits each with a bud. Suckers and bits are treated with hot water or with nematicides before planting.

If corms are used as planting materials, appropriate sucker is selected, peared, washed and splitted into many parts depending on the size of the corms. A corm bit should have at least one healthy bud. Bits are planted 20 to 30 cm deep with buds facing downward and the cut surface upward to avoid rotting.

Using corms or corm bits is preferable if treatment against nematodes and weevils is necessary. Besides, they are easy to be transported long distances and they also provide more planting materials.

**Tissue Culture**

Though the need and potential is there, in vitro technique is
not used in Ethiopia for the propagation of banana and other crops. In other countries it is employed to propagate disease-free materials commercially. Robinson (1995) lists some of the advantages of in vitro techniques as:

- rapid multiplication of a new clone for original plants,
- production of pathogen free plants,
- saving of time and nursery space, and
- regulated nursery production.

The only disadvantage mentioned is its high cost which is expected to lower as the technology develops.

The type of planting materials is important for success which depends on the growing conditions, availability of different planting materials, and the capacity of the producer. In optimum growing conditions (fertile soil, adequate moisture, etc), several planting materials perform well. As the growing conditions become sub-optimal, the larger corms or pieces are preferred.

In general, small suckers give rise to more slowly growing plants which take longer time to bear. On the other hand, handling of large suckers is difficult. Hence, a medium size needs to be chosen to reduce cost in handling the materials. Suckers are preferred to bits and large suckers are preferred to small ones. It's recommended that about 3 kg is the right size for suckers.

After uprooting the sucker, removal of all the leaves and roots is needed. Paring corms reveal the presence of weevil. If there are black holes, it is for the presence of weevil and such
suckers are not used as planting materials. Paring also minimizes nematode incidence.

Suckers may be planted on the same day they are uprooted. They can also stay unplanted up to two weeks if they are not exposed to direct sunlight. Hence, they need to be covered with leaves to prevent moisture loss. In cases where nematodes and weevils are prevalent, the planting material needs to be treated, before being planted, with nematicicides, hot water, and insecticides as the case may be. Furadan 5G at the rate of 1 kg in 20 liters of water, for example, controls both banana weevils and nematodes. Corms and bits are soaked in the solution for about 12 hours.

Sources of Planting Materials

Nurseries
The major sources of planting materials are special propagation nurseries. At present there is no government or private propagation nursery that propagates and distributes planting materials of horticultural crops to users. Though many varieties with various merits are developed in the research centers, they do not reach producers. The research centers do not have the capacity and the mandate to propagate in large scale. Banana is a vegetatively propagated fruit. If a spacing of 2.5 m. between plants is used, 1600 planting materials (suckers, or large bits) are required per hectare. This is 4800 kg if 3 kg is an average weight per seed.

Plantations
Using surplus suckers from commercial fields or gardens is another source of planting materials. Old or abandoned
plantation can serve as a source. But, the variety and health of the planting materials are not known.

**Banana Nursery**

If a number of planting materials are needed for new plantation or extension purpose, establishment of banana nursery is important. For this purpose disease free fertile piece of land is selected. As a result, disease free planting materials of selected variety or varieties are obtained. As opposed to scarce production field, narrow spacings are used.

Desuckering is not necessary in the nursery. Rather, parent plants are decapitated at flowering so that reserves in the pseudostem and rhizome are available for the crop of suckers. This also helps to avoid shading since young suckers need maximum light. Suckers are removed continuously as they reach the recommended size. Up to 10 vigorous suckers per parent are obtained in this way. Ratoon cycles are possible by leaving one of the suckers. According to Robinson (1995), number and vigor of emerging suckers decline with each ratoon cycle. Nursery sucker production can be boosted by suppressing apical dominance, but retaining the foliage.

Care should be taken to avoid inferior planting materials such as small 'bits', broad-leaved water suckers and materials from either very young or very old stools. The nursery should be kept under constant observation so that appropriate measures will be taken against observed diseases and insects.
Land Preparation and Planting

Site Selection

There are certain procedures to follow to establish new and large banana plantation. Soil is the most important factor that determines success. Hence, the pH and chemical composition of the soil need to be determined by taking soil samples from a representative production area. Plantation requires flat topography, well drained, deep and fertile soil with high water holding capacity. Root development is affected by the presence of a hardened layer in the soil, the compact clayey subsoil and the presence of water-bearing strata just below the surface. Such conditions should be avoided.

Saline and alkaline soils need to be avoided. Adequate moisture in the form of rain and/or irrigation must be available. Communication is another point to be considered before the establishment of large plantation.

Land Preparation

Land preparation is not a big concern in traditional banana production. In small or large scale monobanana production, the selected area is cleared of trees and bushes. Banana roots can penetrate neither compact soil nor hard pans. Thus, it is highly recommended to plough the soil deep and disc before planting. This needs to be practiced at least in planting rows. If the field is to be irrigated, it needs to be terraced along the contour. Phosphorus and potash fertilizers can be applied and incorporated into the soil before planting. In relatively sloppy areas, precaution must be taken to avoid soil erosion.
Spacing
For home garden, relatively narrower spacings are used and more plants are allowed to grow per hill. Whereas, for large scale commercial production, choosing the correct plant population is very important to maximize the yield and quality of produce. Population also depends on location, soil type (including fertility), management level, and varieties used. Inadequate light results from use of narrower spacings and/or excessive suckering in the absence of pruning (desuckering). Wider spacings, on the other hand, may reduce productivity and enhance weed growth. Local experience is very important to determine the right spacing and the number of suckers per hill at any given time.

Relatively larger density is recommended for warmer production areas while lower density is for cooler regions. Fertile soil and intensive production can tolerate more population than a relatively poor soil and an extensive production system. High density is related to long crop cycle, smaller bunches and smaller fruit size, but the total yield per hectare will increase due to the greater number of bunches. As opposed to other fruit crops, population in banana depends on original spacings used (plant crop) and number of suckers allowed per hill in the second and subsequent ratoons (ratoon crops).

Traditionally, square or rectangular arrangements are used in commercial banana production in the country. Equilateral triangle arrangements are advantageous for having a 15% population increase and more space for root development compared with the same spacing in square or rectangular system. The latter does not lend itself to irrigation and other
routine practices done by machines. Various combinations are presented in Table 1.

Table 1. Population of mother plants per hectare for various spacing combinations

<table>
<thead>
<tr>
<th>Type of arrangement</th>
<th>Spacing (m)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>2 x 2</td>
</tr>
<tr>
<td>Rectangular</td>
<td>2500</td>
</tr>
<tr>
<td>Equilateral</td>
<td>2890</td>
</tr>
</tbody>
</table>

The spacing between rows and plants can be manipulated to get the desired number of plants per hectare and to make it convenient for routine cultural practices such as cultivation, irrigation, harvesting, transporting products, etc.

A population of about 1600 is obtained by using 2.5 m between rows and plants and 2.0 m between plants and 3.0 m between rows. Two thousand plants per hectare can be obtained by using spacing of 2.5 between rows and 2.0 m between plants or 2 m between plants in the row and between adjacent rows and 3 m between rows every two rows. The wider spacing between rows provide space for routine operations in the plantation.

Many research results abroad revealed that square, nearly square, and hexagonal plantings with single plant are superior in their yield than other arrangements. This is due to the use of maximum available radiation. For mechanized farms wider spacing between rows are used.
Hole Preparation and Planting Depth
Holes with 50 cm diameter and 50 cm depth are dug using the recommended spacing. The top soil is mixed with starter solution and returned to the soil. If possible well rotten manure is added to the top soil. Then, the sucker is placed and sub-soil is returned.

Planting depth depends on the type and size of planting materials. Deeper planting is recommended to reduce wind damage at latter stage. Besides, shallow planting results in ratoon followers that have shallow root systems with part of the rhizome developing above soil level. A 30 cm planting depth is adequate for sword suckers.

Robinson (1995) suggests that side bud on bits should be 20 to 30 cm below the soil surface, and all buds should face the same direction. This avoids drying out of the materials and development of superficial root system. In the case of pared suckers and bits, at least a 10 cm deep soil should cover the cut pseudostem surface.

The soil around the sucker is pressed well to have good contact of the soil and the sucker. For large scale production, a furrow is made and suckers or chips are placed using the recommended spacing. If there is no adequate moisture in the soil, watering is needed.

Time of Planting
Banana can be planted at any time provided that there is adequate soil moisture. Planting at the beginning of a rainy season is preferred to benefit from rain water and good growing environment. Another factor to be considered is
timing the crop harvest to coincide with high market price. This is particularly true for the plant crop and is influenced by many other factors. Sucker emergence is mainly affected by cold, hence avoid cold season planting (October to January around Nazret).

**Crop Protection**

**Diseases**

Diseases are caused by parasitic micro-organisms and/or unfavorable environmental factors. Environmental factors are non-infectious and are caused by climatic conditions like amount and distribution of rainfall, temperature, and light; adverse soil conditions; cultural malpractices; etc. Environmental factors, apart from their importance in their damage, also decrease the resistance or tolerance of the plant to infectious diseases.

**Nematodes**

Surveys made in the research centers and production fields reveal that burrowing nematode (*Radopholus simillis*) is the major pest on banana. However, proper assessment is not made on the presence of other nematodes, and the damage level they cause is not understood.

Plant parasitic nematodes damage the root system, disrupt the root anchorage and cause the plant to fall. Nematode infection affects vigor of the plant which will result in its producing smaller bunches with shorter fingers and elapses of longer periods between the ratoon crops. The incidence is

[23]
aggravated by wind, low population per hill, heavy bunches, heavy rain, etc. Infected planting materials are the causes of wide distribution of nematodes.

Symptoms: According to Gowen (1995), nematode lesions that develop on primary roots can be readily diagnosed by the color of the necrosis and the absence of discoloration of the stele when the roots are cut longitudinally.

Factors affecting nematode damage Nematode population is influenced by the variety used, soil fertility and plant vigor. At present there are no nematode resistant varieties. Among Cavendish varieties observed under Middle Awash condition, Dwarf Cavendish is relatively susceptible than Poyo and Giant Cavendish. As a result its use is discouraged in many areas. This calls for a comprehensive study of the recommended varieties in the pipeline. Damage caused by nematode increases with a decrease in soil fertility. Losses through uprooting are high on loose soils.

Any factor that reduces the vigor of plants, low soil fertility, and cultural practices hastens nematode damage. On the other hand, fertilization, mulching, and use of varieties with larger root systems reduce the incidence substantially.

Control measures Different methods are used by different producers depending on their resources and levels of understanding. Banana is considered a permanent crop in many areas and does not lend itself to nematode control measures such as crop rotation.

Nematicides. In commercial banana plantation, nematicides are
applied regularly to control nematodes. This has a positive effect on yield and quality and also, it shortens/quickens maturation time. Nematicides are the only option to control nematodes in permanent banana plantation.

From corm treatment studies at Werer, DECP (75% EC) repeatedly applied at a three months interval, followed by Fensulfathion 5% granule applied once at planting, gave the best result. The soil treatment studies at Melka Sedi indicated that Aldicarp (15% granules 15 g/hill), DECP (75% EC 4.8 ml m⁻² and Carbofuran (10% granules 30 g/hill) increased the total yield by 82, 63 and 56% respectively. Nematicide screening trials conducted by the Ministry of State Farms Development on Poyo, indicated 14-20% yield increase with application of Mocop 10 G (32.5 g/hill), Mizol 10 G (30 g/hill), Furadan 5 G (60 g/mat), Temic 15 G (15 g/mat) and Nemacur 10 G (27.5 g/hill).

In areas where banana is not a permanent crop, fallowing or planting non-host crop for a year or more is recommended to decrease the incidence of burrowing nematode. Flooding for six weeks is another cultural method suggested where possible.

Hot water treatment suppresses nematode infection in rhizomes. After excavation, roots should be removed and rhizomes pared to expose any possible nematode and diseases infection. Such materials can be dipped in water of 53 - 55 °C for 20 minutes to reduce nematode problem.

Other suggestions to suppress nematode infestation in rhizomes include trimming diseased tissue with a knife,
dipping rhizomes in nematicide or nematicide impregnated mud, and exposing rhizomes to sun light for 14 days. The safest way to produce disease-free planting material is to use in-vitro techniques.

Other diseases such as Cigar-end rot (caused by *Verticillium* spp.), anthracnose (*Cleosporium musanum*), leafspot (*Mycosphaerella musicola*), and greasy spot on petiole (*Tourlopis* spp. and *Phoma* spp.) were observed in different banana producing areas. The incidence was, however, very light and it did not call for control measures.

**Insects**
According to Tsedeke (1986), a few insect pests such as banana aphid, *Pentalonia nigrinervosa* Coquerel have been recorded on banana in Ethiopia. They are not economically important at present and no control measure is required.

**Weeds**
In banana plantations, weed is serious at the initial stage. Weed problem diminishes as more banana leaves that suppress weed growth develop. Weed is a problem in poorly managed farms and where wider spacings are used. In order to avoid competition for nutrients and moisture, weeds—particularly grass weeds, need to be controlled.

The common weed control measure in Ethiopia is slashing the weeds with *machete* and *jamba*. Laborers should be careful not to damage the bases of the suckers which serve as entrance for pathogens. Chopped pseudostem, leaves and weeds serve as mulch to suppress weed development and to conserve soil moisture. After decomposition, they become source of
There are various herbicides to control weeds but manual uprooting and cultivating is strongly recommended. If it is needed to use herbicides, experience of banana growing countries can be used with caution. Pre-emergence herbicide ametryne is used to suppress general weed growth. Paraquat, a contact herbicide, is applied after 6 months of planting and is effective on broad leaved annual weeds. A systematic herbicide like glyphosate is effective on perennial grass species.

**Wind**

It's nature of shallow root system, heavy bunches, broad leaves and height of some varieties make banana susceptible to wind damage. Strong wind tears the leaves, breaks pseudostem or topples the whole plant. Sometimes wind damage reaches a total loss.

To reduce wind damage, windbreaks are planted on one or more side(s) of banana plantation perpendicular to wind direction. At Melka Sedi, Ducasse Hybrid which is tall and with strong pseudostem is planted closely as windbreak. Use of banana as a windbreak has some advantages. It is established with the crop and is treated as the crop in the production period. It also produces fruits—which is additional income for producers. Various trees are established permanently as windbreak.

**Frost**

In some banana growing regions (relatively high altitudes), occasional frost is experienced during November to February.
This is particularly true for short banana varieties. It is highly recommended to avoid areas with regular frost. A single night with a temperature below the freezing point kills the banana quickly, and may ruin the entire plantation.

Cavendish varieties in general are susceptible to low temperature injury. Dwarf Cavendish is reported to suffer from low temperature effect called 'chock', but Giant Cavendish is less susceptible. Ducasse Hybrid and some plantain varieties are less susceptible. Covering the developing bunches by polyethylene bags reduces chilling injury of the bunches. Low temperature extends the time required for shooting and maturity.

Quarantine
Nematodes, panama disease and bunchy top virus are transmitted through planting materials. Major diseases and pests that are the biggest constraints in the production of banana in the major producing areas of the world are not observed in Ethiopia. Even the observed diseases and insects in the country are not distributed to all banana producing areas.

There is a danger of introduction of pests and diseases into the country. Strict quarantine would be needed if new materials are brought in for testing. Enforced use of tissue-culture-propagated materials will prevent further introduction of diseases and pests through planting materials. Movement of conventional planting materials should be restricted to avoid the spread of insect pests and diseases to the major banana growing areas.
Crop Husbandry

Soil Nutrition

Virgin soils may be fertile, to start with, and hence, they may give high yield of quality fruits. If the land is continuously used for banana production, yield and quality will decline through time. The Banana uses soil nutrients for the production of fruits and vegetative parts. These nutrients need to be replaced in one way or another. Applying organic or inorganic fertilizers and returning the plant residue to the field help to maintain soil fertility.

Banana growing soils vary in their origin, development, and content of essential elements. Attempt should be made to understand the nutritional status of the soil (soil analysis). This will give ideas about the types and amount of fertilizers that are going to be applied.

Fertilizer field experiment results are dependent upon local conditions of climate, soil and cultivars. Hence, they are not directly used for all growing regions. Field experiments coupled with plant and soil analysis enable to estimate the kind and amount of fertilizer required to maximize yield. As indicated by Lahav (1995), amount of fertilizers varies significantly according to the climate, cultivar grown, yield, resources of the grower, his soil and management practices.

Various nutrients are required for proper growth and development of banana. The type, amount, and frequency of application depend on the fertility status of the soil and the stage of growth. It has to be remembered that excess nutrient
of one kind or another may not benefit the crop. In fact, in some cases it has negative effects on crop development. Due to its shallow root system banana gets most of its nutrients from the top 30 cm of soil. Some of the nutrients that add to soil fertility are discussed below.

**Nitrogen**

Application of nitrogen containing fertilizers increases growth substantially. According to researchers, the positive results obtained with nitrogen include increases in the number of bunches and total fruit weight per given area. Nitrogen level also affects bunch maturation period and fruit quality. The source of nitrogen should depend on the pH of the soil of the growing area. Urea is preferred for soils with high pH.

The most typical symptoms of nitrogen deficiency are slow growth, the development of a yellowish-green color in the lamina, and a more or less deep reddish pigmentation in the petiole. Clay and clay-loam soils are prone to nitrogen deficiency if organic matter is depleted. Poor drainage systems and root development cause nitrogen deficiency.

Though from 100 to 800 kg N ha\(^{-1}\) per year is applied in different banana producing areas, about 250 kg N ha\(^{-1}\) per year is usually applied. Lahav (1995), advises to avoid \((\text{NH}_4)_2\text{SO}_4\) and to use urea on acid or poorly buffered soils.
Potassium

Generally, it is agreed that potassium is the most important element in banana nutrition. There are ample reports from the world's major banana producing areas that application of potassium increases both the yield and quality of fruits. It is reported that low potassium levels restrict the transfer of nitrogen, phosphorus, calcium, magnesium, sodium, manganese, copper and zinc.

Though there is a claim that Ethiopian soils are high in potassium, strong response was observed both at Melka Sedi and Awara Melka at least in vegetative development. Unfortunately, the trials were destroyed by animals at the time of fruiting.

A premature leaf yellowing (from the margin inward) is considered a typical symptom of potassium deficiency. The midrib curves so that the tip of the leaf points towards the base of the plant. Other effects of potassium deficiency are choking, delay in flower initiation, reduced fruit number per hand, less hand number per bunch, and especially small fruit size.

Potassium deficiency is sometimes associated with high pH value and with the presence of much free calcium and root damage caused by drought. There is variation among varieties in their susceptibility to potassium deficiency. Excess potassium over nitrogen causes a premature ripening of fruits (yellow pulp).

On poor soils application of large amount of potassium (about 2000 kg ha⁻¹) is suggested. Potassium fertilizers are not
available in the country. In other countries, potassium chloride is the major source of potassium for banana production. In areas where salinity is a problem, potassium sulphate is recommended not to aggravate the case.

**Phosphorus**

Phosphorus requirement of banana is not large as opposed to its high demand for potassium and nitrogen. According to Lahav (1995), this is due to a relatively small quantity of phosphorus expected with the fruit; and that phosphorus is easily redistributed from old to young leaves, from leaves to the bunch and from the mother plant to followers.

Characteristic symptoms of phosphorus deficiency include very stunted growth and poor root development. The leaf symptoms include severe marginal scorching, shrinkage of older leaves and poor leaf development.

The most common phosphorus source in Ethiopia is diammonium phosphate (DAP). The fertilizer provides both phosphorus (46%) and nitrogen (18%). About 100 kg P ha⁻¹ annually is commonly applied for banana. For crop plant, phosphorus fertilizer should be incorporated with the soil before planting. For subsequent ratoon crops it is broadcasted with other fertilizers.
Other Elemental Fertilizers
Other elements are not commonly considered for banana production in Ethiopia. Though they are required in smaller quantity, many of them are essential for high yield and quality fruits. Regular application of the needed micronutrient is recommended.

Deficiencies of magnesium, calcium, sulphur, manganese, iron, zinc, copper, etc. have characteristic symptoms which enable producers to identify the problems. Such topics are beyond the scope of this handbook.

Organic Versus Inorganic Fertilizers
Application of manure is highly recommended to improve the nutrient status, water holding capacity and texture of the soil. Due to unavailability of large amount of manure and cost of application, it is impractical to use it for large scale banana production. Commercial level banana producers commonly use elemental fertilizers.

On the other hand, it is not economical to use elemental fertilizers for garden crops. Here, the fertility of the soil is maintained by the addition of residue from harvested plants, ash, kitchen waste and manure of various sources. Preparation and use of compost need to be encouraged. Farmyard manure (FYM) up to 80 t ha⁻¹ per year enhances growth, hastens flowering and shortens the period between flowering and harvest. Lahav (1995) reported that farm yard manure alone increases the yield by 33%. He suggests application of FYM with elemental fertilizers. In all cases, the organic fertilizers need to be incorporated into the soil.
Time and Method of Fertilizer Application
It is advisable to apply and incorporate insoluble fertilizers and manure before planting. Depending on the situation, nitrogen fertilizer is applied up to four times a year. This is because nitrogen is not accumulated in the plant and the nitrogen in the soil is leached by rainfall and irrigation. In areas where irrigation is practised the best way of nitrogen application is with irrigation water.

Moisture (Rainfall/irrigation)
Banana has high water demand throughout the year due to its high transpiration and shallow root system compared with other tree fruit crops. Wardlaw (1972) states that water is probably the most important single factor affecting growth of every organ of banana. For maximum production, there must be adequate water in the form of rain or irrigation.

In areas where the amount (about 1000 ml) and distribution of rainfall is adequate—as in Mizan Teferi and Tepi, banana is produced under rainfed condition. The distribution of rainfall, is as important as its amount. An area that receives high amount of rainfall, say for eight months, but remaining dry for the rest of the year, is not suitable to produce banana under rainfed condition. This area definitely requires supplementary irrigation.

In areas like Melka Sedi, Awa Melka, Dubti and Arba Minch where the rainfall is limited and evapotranspiration is very high, banana production depends entirely on irrigation. Intermediate regions between these two extremes may need supplementary irrigation during dry spell. The amount and frequency of irrigation water vary depending
on temperature, amount and distribution of rainfall, the stage of development, and the soil's water holding capacity which in turn depends on soil types. Water holding capacity is high for clay loam soil followed by sandy clay, loam, sandy loam, loamy sand, and coarse sand.

In general, for middle Awash where the rainfall is low and evapo-transpiration is high, it is recommended to apply 10 cm water every three weeks except in May and June, when frequency is reduced to two weeks to cope up with the high evapo-transpiration rate. Usually less amount but more frequent irrigation is needed at early stages as opposed to later stages of growth.

Too much irrigation water has negative effect on plant development, soil pH, and it also makes cost of production unnecessarily high. Excess irrigation coupled with lack of effective drainage system resulted in abandoning large areas of productive land (about 400 ha) at Melka Sedi due to salinization. Such land can be reclaimed by applying ample irrigation water and by constructing good drainage system. But the cost is prohibitive. The simplest and effective way is to use efficient irrigation system.

Together with the annual precipitation, total water budget for banana was calculated to be 245 cm as opposed to the 350 cm applied by state farms. Banana is particularly sensitive to stagnant water. Hence, optimum care should be given to drainage.

Irrigated areas and high rainfall areas with flat terrain require
drainage systems to ensure free downward and lateral water movement, aeration, and leaching of high concentration of salts.

Among the main irrigation systems used to supply water to banana in Ethiopia is flood or furrow irrigation system. In this system one or group of hills are flooded. Costly soil leveling, uneven distribution of water and fertilizers, and spread of nematodes with the moving water are cited as the weak points of the system.

In other major banana growing countries, the furrow irrigation system is substituted with more efficient systems like using overhead sprinklers, under canopy sprinklers, and microjet and drip irrigation systems.

**Sucker Management**
Sucker management in banana production has two major components. These are desuckering and selecting ratoon suckers.

**Desuckering**
A single banana `seed` may be planted. Then, before the removal of the mother sucker but after the harvest of the bunch, the seed may form one or more well grown daughter plants. The process is continuous and numerous suckers will develop unless unwanted suckers are removed. Allowing many suckers per hill results in unnecessary competition for soil nutrients, moisture and light and also extends the cycle. This, in turn, results in lessening both the yield and quality of fruits. The process of destroying surplus suckers, called desuckering, is, therefore, necessary.
In Ethiopia lack of sucker management is one of the major reasons for low yield and low quality of banana. In traditional banana production, bananas are left to reproduce by themselves. Desuckering is not practiced in many production fields. As a result, it is not surprising to see up to 25 suckers per hill.

The common desuckering method in Ethiopia is severing the sucker with machete. This method assists the spreading of soil-borne diseases and nematodes from hill to hill. Robinson (1995) explains that in South Africa sucker is cut down, a small cavity in the center of the cut surface is gauged, and 2 ml of kerosine is poured. The kerosine moves downwards and kills the meristem to prevent sucker growth. This method does not damage the roots and what is more, it avoids the spread of diseases and nematodes from hill to hill.

Desuckering should be done at an interval of one month. All unwanted suckers with 30 cm or less height are removed.

*Sucker selection* As to Robinson (1995), selection of the correct follower is one of the most critical operations in a banana plantation. This is not recognized in Ethiopia, thus resulting in low productivity and poor quality fruits. In sucker selection, there are three important aspects to be considered. These are stage of parent plant development, number of suckers to select, and direction of selection.

At any given time it is suggested that a hill should comprise a bearing mother plant, a large daughter sucker and a small granddaughter sucker. This is particularly suitable for
narrower spacings commonly used in Ethiopia. Sucker selection can take place when the large daughter sucker becomes a bearing mother plant. Hence, only one sucker is selected per hill at one time. Selected suckers must be of the same size and must be in the same direction of the row. Direction of selection is very important to maintain the original rows (spatial arrangements) which in turn facilitate routine cultural practices.

Suckers grown haphazardly will interfere with routine cultural practices such as harvesting, cultivation, irrigation, etc. If larger spacings are used (3 m × 3 m or more) two or more ratoon suckers are selected for ratoon crops. The first selection could be about seven months after planting.

**Bunch Management**
Depending on the growing area and the cultural condition, banana plants start to produce inflorescence after 9 to 12 months of planting. The number of hands depends on the variety and nutritional status of the soil. Therefore, handling of the plant prior to flowering (bunch inception) is very important.

The time taken from shooting of the bunch to harvesting is about three months. Under ideal growth conditions, a good banana 'seed' shoots in seven to nine months of planting and then yields bunches in three months.

**Bunch Propping**
Falling over of pseudostem with bunches is a major problem in banana production. This brings about a total loss of bunches. Lodging of plants is caused by one or more of the
following factors: wind, weak pseudostem, poor anchorage, large bunches, and damaged rhizomes—those attacked by soil born diseases and pests (weevils, nematodes).

Attention should be given to minimize the root causes by constructing windbreaks, selecting suitable varieties and appropriate followers, and protecting plants from soil borne diseases and pests. In spite of all these efforts some plants may lodge. Bunches need to be supported before they fall. Wooden props are used in areas where they are inexpensive and easily available. Single and double props are used for short and tall cultivars respectively. Props should be clear of the bunches to avoid fruit scarring.

**Bunch Trimming**

Robinson (1995) puts that the removal of the withered floral remnants of the fingers reduces fruit scarring, improves appearance, and serves a precautionary measure against fungal infection causing cigar-end rot. The remnants of the fingers are easily removed by hand eight to twelve days after flowering. This is practical for short cultivars such as Dwarf Cavendish.

Removal of the male flower bud is commonly practiced to avoid unwanted part from the bunch which is a possible site for thrips and mites. Increase in bunch weight due to the removal of the apical meristem is reported in Israel and Mexico. It is also noted that the period of fruit development from shooting to harvesting is reduced by about two weeks. The bell should be removed and the cut edge should be wrapped in a fungicidal pad, when the distance between the distal hand and the top of the flower is 15 cm.
**Bunch Cover**

Robinson (1995) notifies that in both tropical and subtropical banana growing countries, the use of polyethene bunch covers is virtually universal and is now regarded as an essential technique to improve yield and quality of banana bunches.

Many researchers reported that bunch cover increases the yield and quality of fruits and results in reducing emergence to harvest time. This is expected as a result of creation of microclimate in the bag. This is particularly true in the higher altitudes where subtropical conditions prevail. In the lowland the major advantage of polyethene cover is mechanical protection of the fruit from wind and hail damage, fruit scarring insects, sun scorch and from damages during harvesting and transporting.

Such a covering is not commonly used for banana produced for home consumption and for the cooking type. Polyethene tubing (translucent blue) covers are applied after the bracts are fallen, the hands have curled upwards, and the flower ends have hardened. To reduce build-up of temperature and pest problems the bags are perforated or pesticide impregnated covers are used.

**Other Operations**

**Leaf Removal**

Healthy and well grown banana plants normally have 10 to 15 functional green leaves. The leaves emerge at the rate of 10 to 20 days based on the growing conditions and varieties. The number and condition of leaves has direct relation with the
yield and quality of fruits.

Untattered leaves may be removed from the banana plant for various reasons. If 50% of the leaves are infected with leaf-spot diseases, they are removed to reduce spread of the disease. Senescent leaves which are no longer useful are also removed to facilitate light penetration. The third group of leaves to be removed are healthy leaves that rub with young bunches. This is done to avoid scratches on the young bunches. Removed leaves except those infected with disease can serve as mulch.

**Intercropping**
Under rainfed condition banana is commonly intercropped with many other food and cash crops. This is mainly to avoid risk, to get food for home consumption, and to obtain cash from surplus. The crops involved are beans, enset, coffee, taro, yam, cassava, cereals and spices. In general banana is least affected by intercropping than the other intercrops. Total income from intercropping is usually higher than that from a pure stand in banana based system of extensive small holding situation. There is room for improvement and the system needs to be studied well. Vegetables and other annuals are produced between rows of 'plant crop' banana.
Mulching
Mulching is the process of covering the soil surface around the hill with organic and inorganic materials to reduce evaporation, to suppress weeds, and to regulate soil temperature. Various materials such as black polyethene, grasses, coffee hull, banana trash or other locally available materials are used. In banana growing areas, banana trash is available at harvest. It is used as organic mulch in commercial and traditional banana production both under rainfed and irrigated conditions. It is a nuisance unless it is disposed properly. Old pseudostem, after bunch harvest, is cut down about 10 cm from ground level. Banana pseudostem and leaves are chopped to facilitate decomposition and are placed around the hills. This practice improves the organic status of the soil through time.

Mulching is practiced in many traditional banana producing areas. Subsistence farmers cannot afford to buy elemental fertilizers. Hence organic mulching is the only source of fertilizer besides manure and household refuses. As a result, the fertility of the soil is maintained and sustainable banana production is possible.

Ratooning/Plantation Life
In traditional banana production, plants are left indefinitely provided that they give some fruits. At Melka Sedi plantations of more than 14 years old are in existence. Due to poor management, the yield is considerably low (5 t ha⁻¹ per year).

The major factor that determines plantation life in other banana growing countries is yield decline resulting from
build-up of nematodes, loss of spatial arrangements, soil compaction, low soil pH, soil fertility decline, etc.

**Crop Rotation**
Except for plantations in state farms and recently small scale banana production around Arba Minch, Tepi, and Mizan, monocropping banana plantation is not common. Monocropping effect on yield and quality is not studied. Yield decline is observed at Melka Sedi. This is partly attributed to salinity and poor management.

There is no doubt about the benefit of crop rotation. In similar banana growing countries, lack of crop rotation is considered a major constraint in banana production. Monoculture banana production in Ethiopia is expected to face the same problem. Crop rotation results in reduction of root insect pests and nematodes, improved soil fertility and increased organic matter. Rotation crops that are not host to nematodes and that increase soil fertility need to be identified.

**Productivity and Quality**

**Productivity**

Average yield of plant or ratoon crops in Ethiopia is considerably low compared with other banana growing areas. Actual productivity is not known for sure but subsistence farms and commercial plantations are not getting greater than 10 t ha\(^{-1}\) annually. Thirty to seventy tons/ha per year is common in commercial plantations in other banana growing countries. In Ethiopia very little research
technologies such as cultivars, fertilization, irrigation, spacings, sucker management and plant protection are used.

Poor drainage, over irrigation, inadequate fertilizer inputs, and absence of sucker management have been identified as the principal causes for low yield and quality in state farms. There is a big gap between the potential (experimental plot) and the actual yield. Hence, there is a great opportunity to increase yield and quality of banana both in traditional and commercial plantations using the existing available technologies. To improve the yield and quality to the level of the other banana growing countries, full attention should be given to banana research and development.

Quality
At present the demand for banana exceeds the supply. The demand is steadily increasing. As a result any fruit can be easily marketed. This will not remain as it is. Time may come that producers will be paid both for the quality and quantity they produce. Besides different types will be required for different purposes. Thus, grouping by use and grading by qualities will come into practice. Size, shape, color, flavor, appearance, etc are important.

Pre-and post-harvest handling such as spacings, sucker management, fertilization, irrigation, plant protection, maturity standards, transportation and ripening methods, and handling fruits which have impact on fruit quality need to be considered seriously.

Among the 10 cultivars evaluated, Giant Cavendish, Poyo and Dwarf Cavendish are found to have a distinct and strong
banana flavor. The above cultivars also gave a high percentage of total soluble solid. Longer and relatively slim fruits contribute to their acceptance by consumers. This is true for commercial dessert type. Other varieties which are considered relatively 'poor' are either cooking or beer types. It is not fair to test them for the purpose they are not intended for.

**Harvesting and Post Harvest Handling**

In the past banana was used to be handled carefully in Melka Sedi farm. Bunches were cut carefully and transported to packing station. Their hands were cut from the bunches trimmed and washed by floating in tank. Then, they were treated with fungicides to eliminate fungal infection. The fruits were drained and packed in fiber-board boxes. Next, fruits were transported to a distant market where they were ripened. There were cold storage facilities there. So far banana was not processed at commercial level in Ethiopia.

**Maturity**

The time required for banana to reach maturity depends on the type and variety of banana, type and size of planting material used, fertility of the soil, the cultural practices followed (fertilization, irrigation, disease and pest control methods, etc.), the growing environment, etc. As a result it takes from less than one year to two years for a banana to give mature fruit from planting. Normally it takes about three months from flowering to harvesting.
Harvesting
Stage of maturity for harvesting bananas depends on the market for which it is intended, the type and marketable life required. East African highland cooking type is harvested and cooked green. Dessert and plantain are consumed ripe. The age of the bunch, angularity of the fingers, pulp to peel ratio, diameter and length of banana fingers, and firmness of the fruit are used as maturity indices. For its practical value, angularity of the fingers is recommended particularly for traditional banana growers.

Therefore, time of harvest is determined using a stage of development which is assessed subjectively by the shape of the fingers. Fingers are angular and considered 'thin' when immature and are considered 'full' while still green to rounded shape. Usually the outside whorl middle fingers of a middle hand are evaluated to determine maturity.

Because too immature fruits do not attain their normal size and will not ripe normally; bananas have a short shelf life after ripening; and ripen fruits are difficult to handle for distant markets, bunches are harvested from three-quarters (still slightly angular and somewhat immature) to heavy full (well rounded and just fully matured). Fruits are harvested at fuller maturity for nearby markets and thinner for distant markets. For dessert type the best fruit is that which normally ripens on plants. Such a fruit will not reach distant market safely.

Mature fruits are susceptible to physical damage that may be caused by post-harvest mishandling—transporting, storing, and marketing. They may also split during handling.
Physically damaged fruits are unsightly. If the damage is severe, the edible pulp will break down and the wound will be an entrance to pathogens which cause decay.
Skin discoloration can be tolerated in domestic markets provided that eating quality is not affected. Appearance for banana to be exported to developed importing countries is important.

During harvest, care should be taken not to let the bunch fall on the ground and get damaged. For short varieties one person can use machete to cut the bunch while the other one carrying the bunch. For tall varieties, the bunch should come down by making a cut on the stem at a two-third height. Then the bunch is cut off and carried out.

**Packing**
The packing station should facilitate operations such as delivery of the produce, dehanding, selecting and grading of the produce, washing, treatments against diseases (chemical), packing and distribution. Appropriate care should be taken in the selection of location for building. Some years back there was a modern packing station at Melka Sedi with all the necessary facilities. With a continuous decline in production, productivity, and quality of the produce, the packing station became non functional. Currently, there are very minimum operations in some state farms.

Cutting of the hands from the main bunch, and putting them in boxes (wooden, plastic or fiber board) reduce the physical damage incurred during transport. To further reduce the damage, the boxes can be lined with banana leaves. Whenever possible, washing fruits to remove dirt and latex and treating them with fungicides helps a great deal to maintain quality and to reduce losses due to diseases like crown rot. Dehanding and packing can be done in the field.
**Transportation**

In the peasant sector human labor and draft animals are used to transport bunches from production site to central areas. Here bunches are piled and covered with banana leaves. In state farms bunches are usually cut off from the plant and carried to the edge of the field and then transported to packing house. Padding the floor of the trailers or vehicles with banana leaves is recommended to reduce physical damage.

Large trucks are used to transport unripe banana from major growing areas to big cities. Bunches are piled on the truck loosely and then covered with banana leaves. Due to the distance from the growing areas to cities, fruits may stay on truck for a day or two. It is not surprising if fruits are physically damaged. The Cavendishes which are the common dessert types produced in Ethiopia are relatively susceptible to mechanical injury. Crating or boxing is not practiced.

Mechanical damage incurred during harvesting, packing operation, and transportation is not always clearly visible on unripe fruit. However, on ripening it may greatly reduce the market quality. Due to its perishability, optimum care should be given at times of loading and unloading to reduce losses due to fruit damage. Direct sun light and conditions that lead to dehydration should be avoided from harvest to consumption.

Due to lack of refrigerated vehicles for the transportation of banana, it is practically impossible to maintain the recommended temperature during transit. Temperatures above 20°C accelerate ripening. Attempt must be made to
maintain the temperature of fruits as low as possible (12°C) after harvest particularly during transport. Driving trucks in the morning or at night when the temperature is low and parking them under shade is expected to help.

**Storage**
Unlike for other fruits and vegetables, seasonality of supply is not a serious problem for banana. In most banana growing regions, banana fruits are harvested throughout the year and are, thus, freshly available for consumption. Hence, prolonged storage is not needed as it is the case with seasonal crops. However, keeping banana for few days under good conditions is important in its marketing and utilization. Banana should not be exposed to temperature less than 10°C before or after ripening. Exposing ripe fruits to sun light results in the darkening of the fruits.

**Processing**
Various products are processed from banana. Some have acceptance by consumers and also offer economic values. Alcohol, banana juice, wine, beer, crisp, jams, jellies, puree, dried bananas or fig bananas, natural cream, cream with additional fats, slices of green banana, flakes, powder and flour are some of the products.

Banana flour is a product obtained by drying and then grinding green bananas. The flour is extremely digestible, easily absorbable, and is used in the preparation of special foods for babies and old people.

[50]
The present supply and demand of banana may not call for processing of the plant. Anything produced is consumed regardless of the quality. The priority at hand is to produce and deliver quality fruits to satisfy the demand.

**Ripening**

Banana is a climacteric fruit. According to Thompson and Burden (1995), climacteric fruits increase in size and accumulate carbohydrate in the form of starch. When the fruit is fully mature, growth ceases and the ripening phase starts. During ripening the fruit softens, starch is converted to sugars, the color of the peel changes from green to yellow, astringency of the fruits is lost, and characteristic flavor develops.

Fruits ripen on plants are the best fruits. This is only possible in banana growing regions. For long distance markets, mature green fruits are harvested to ease post-harvest handling. These fruits are transported to cities or towns where they are going to be marketed. The green fruits have to be ripened before sold to consumers. Before placing the fruit in special room to ripen, broken and immature fruits are removed from bunches.

The state-owned marketing enterprise, Etfruit, receives green fruits both from state farms and individuals. It ripens the fruits in rooms built for this purpose. The rooms are equipped with electronic device for ventilation, but they are not functional at present. Banana hands are put into plastic crates and are piled in these special rooms. Rooms are air tight and kerosine lights are on during the ripening process. The enterprise has ripening rooms in its first (Kapele) and second
(Montinare) distributing centers. There is a plan to establish one at Debre Zeit Distribution Center.

There are many private ripening rooms. Here bunches are piled on the floor. There is a possibility of physical damage for bunches on the floor due to the weight over them. As Etfruit’s ripening rooms, these, too, have no control mechanisms for temperature, humidity and ventilation. Vertical stacking of bunches reduces physical damage and facilitates air circulation to minimize the heat generated during ripening. For hard green fruits, high temperature and high relative humidity (90-100 %) are provided. As soon as color change is observed, the humidity should be lowered to 75-80 %. The recommended temperature of the room ranges 15-21°C depending on the state of the fruits on arrival and the demand for ripe fruits.

Ripening at lower temperature yields fingers with green tips and necks which is very attractive for distribution to retailers. For slow ripening, ‘three-fourth full’ and ‘full’ fruits are held at a constant temperature of 14.5°C.

Ripening of green banana can be initiated by many means. The methods vary depending on the scale of operation and the availability of facilities. As stated earlier, fruits ripen on plants are the best. Wounding the bunch stalk, adding salt and keeping it warm initiate ripening of the bunch. Ripen banana fruits are stored with green fruits to initiate ripening. A smoky fire in ripening room initiates ripening. This is due to ethylene and related gases that initiate ripening.

[52]
Ethylene (1000 ppm) or acetylene is supplied at low concentration to stimulate the onset of ripening in hard, green fruits. Locally, this is accomplished by burning kerosine light. Ripe fruits need to be stored at lower temperature but at not less than 13°C. The purpose of controlled ripening is to schedule and manipulate marketing. The size of the room is determined by the maximum daily demand and by the frequency with which green fruit arrives.

Proctor (1982) gave an approximate guide that room stocking density should not exceed 1 tone/10 m³ (2 m x 2 m x 2.5 m). According to her, ripening room design follows normal cold store practice with insulation and vapor barrier. Wall and floor surface should be smooth and impervious to facilitate good room hygiene and to reduce ethylene absorption. Large doors are necessary for access and should be designed to fit into a gasket which ensures the room is almost tight.

Reducing Losses
Banana is not handled properly from harvesting to consuming. As a result considerable amount is wasted and the quality of fruits is reduced. This can be improved by proper handling of fruits from field to market. Care should be taken to avoid injury during the harvesting, packing, transporting and marketing of fruits. Bunches, after harvest, should be carried to central point with care. The central point needs to be under shade and bunches should be covered with banana leaves. Padding trucks with banana leaves reduces physical damage.

Dehanding and packing into boxes is highly recommended for transport. If this is not possible, the floor and sides of the
vehicle need to be lined with banana leaves and bunches should be stacked vertically not horizontally. If the bunches have to be stacked horizontally, they should be in layers with banana leaves between each layer. Careful handling at all stages of operation is emphasized to reduce damage and to maintain quality.

There are some sorts of ripening facilities in large cities. In ripening rooms, it is advisable to stack boxes not bunches. This provides good air circulation and reduces physical damage by fruit weight. Care should be taken not to over-fill boxes to avoid fruit crushing during stacking. If bunches are to be ripen, they must be hanged up to allow good air circulation. If this is not possible, vertical stacking is recommended.

Reduction in wastage—particularly during production, transport, ripening and marketing—is much important than processing. Sometimes it is not possible to transport what is produced from the production area for various problems, mainly lack of organized marketing system in the production areas.

Farmers have small plots and produce small amount which is not enough to call a truck. They are under the mercy of merchants. As consumers become conscious of quality, there would be rejects that need to be utilized somehow.

**Marketing**
Banana is a perishable commodity. It must be consumed in few days after harvest. Producers cannot store banana on plants or in store. So, they should dispose it right after
harvest. In banana growing areas banana is marketed mainly
on the road for passengers, drivers and their assistants. Well-
ripen fruits, mostly hands and fingers, are marketed. No
special care is taken here. In large cities like Addis Abeba,
there are two ways that bananas are marketed: wholesale and
retail. There is a big difference between wholesale and retail
price by merchants. Etfruit plays significant roles in regulating
the price of banana and in making the product available to
consumers.

**Private Merchants**

At present, the major sources of banana to Addis Abeba and
other cities are Arba Minch area, Mizan Teferi, Tepi, Awara
Melka and Melka Sedi. There is preference to Arba Minch
banana by Addis Abeba merchants and consumers. According
to merchants, this is due to high dry matter, long shelf life,
thick and long fruits, non-green tip after ripening, excellent
taste, spots on skin (sign of excellence), deep yellow color
after ripening and high acceptance by consumers.

There are licensed merchants who bring bananas to Addis Abeba in large quantity. These merchants sell banana to those
who have ripening rooms or who ripen their fruits in their
own ripening houses. After ripening, ripen fruits are sold in
bunch to retailers. Retailers finish with the ripening process
by holding them in relatively warmer places (rooms, boxes)
and covering them with newspaper. The retailers believe this
enables the fruits to develop desirable color. Retailers have no
cooling facilities. They hold them under room temperature.
Hands are displayed in front of shops to attract consumers.
Some owners know that exposure to direct sun light will
shorten fruit shelf life. Despite this awareness, they expose
their fruits due to competition with neighboring merchants.
At least shade should be provided to reduce damage. Ripe fruits are highly susceptible to mechanical injury. Bruised ripe fruits have a very short shelf life.

**Etfruit**

Etfruit, government marketing enterprise, receives banana from state farms and individuals, ripens it in its ripening rooms and then sells it to retailers. For its service, it charges the state farms 6% and 7% for whole and retail of the total sell respectively. In the last three years, it marketed more than 34,400 quintals per year, out of this about 80% is from Awara Melka.

At present the demand for banana is greater than the supply. As a result price is expected to rise. Simple observation of the marketing system reveals that the middlemen are the beneficiaries than the producers. Producers (farmers) have no incentive to expand banana production due to low price for their products. Consequently, consumers are not encouraged to consume more due to high price. Involvement of Etfruit in the purchasing of banana directly from producers may have a positive impact on the marketing system. Improvement in the marketing system plays important role in banana development of the country.

Individual farmers cannot afford to transport their produce to the market. This is particularly true for farmers with poor income and those that are far from major markets. Formation of producers' cooperative is strongly advised from technical, economical and social points of view. Producers will sell their produce through their cooperative and also will have a better bargaining power. The association also assists producers in
getting agricultural inputs and advises from extensionists and researchers. Such cooperative is getting credit to improve yield and quality of banana of the area, This in turn reduces price for consumers and increases per capita consumption.
REFERENCES


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