Plantain Cultivation under West African Conditions

A Reference Manual

INTERNATIONAL INSTITUTE OF TROPICAL AGRICULTURE

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PART ONE Plantains and their environment

Plantains are starchy bananas which make up one-quarter of the total world production of bananas (*Musa* spp.). Unlike the sweet dessert bananas, plantains are a staple food which is fried, baked, boiled (and then sometimes pounded) or roasted, and consumed alone or together with other food.

About 70 million people in West and Central Africa are estimated to derive more than one-quarter of their food energy requirements from plantains, making them one of the most important sources of food energy throughout the African lowland humid forest zone.

In Africa, plantains are grown for home consumption, not for export. The area between the lowlands of Guinea and Liberia in West Africa and the central basin of Zaire in Central Africa produces one-half the total world output of plantains (figure 1). West Africa produces two-thirds and Central Africa one-fifth of the African output. In terms of cost per hectare, per ton and per unit of food energy, plantains are also the cheapest staple crop to produce.

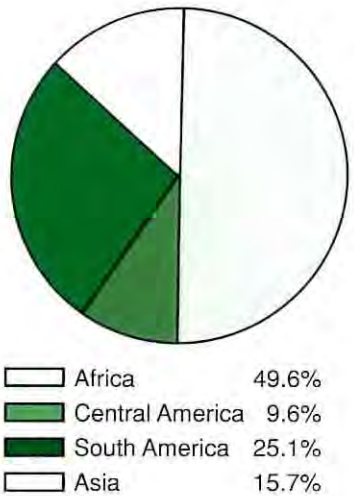


Figure 1
Plantain production by continent

1. Morphology

Bearing plants (figure 2) consist of :

(a) Bunch or inflorescence. Composed of many flowers, the bunch emerges between the leaves and is attached to the plant by a rachis or fruit stalk. The many protuberances on the rachis are called glomerules. Each glomerule bears a group of flowers, also called a hand. Edible fruit (or fingers) develop from female flowers located at the first 10 glomerules of the bunch. Neutral flowers (also called hermaphrodite or intermediate flowers) appear next but do not develop into fruit as their ovaries cannot swell to form pulp. The purple bud at the end of the bunch is called the "male bud" and consists of bracts covering groups of so-called male flowers. This male bud may be absent or present when the bunch reaches maturity.

(b) Pseudostem with foliage leaves. The cylindrical structure rising from the soil and carrying the foliage is not a stem in the true sense. It is a "false" stem or pseudostem because the growing tip (or meristem) of the plant remains near soil level. As the false stem consists of overlapping leaf sheaths,

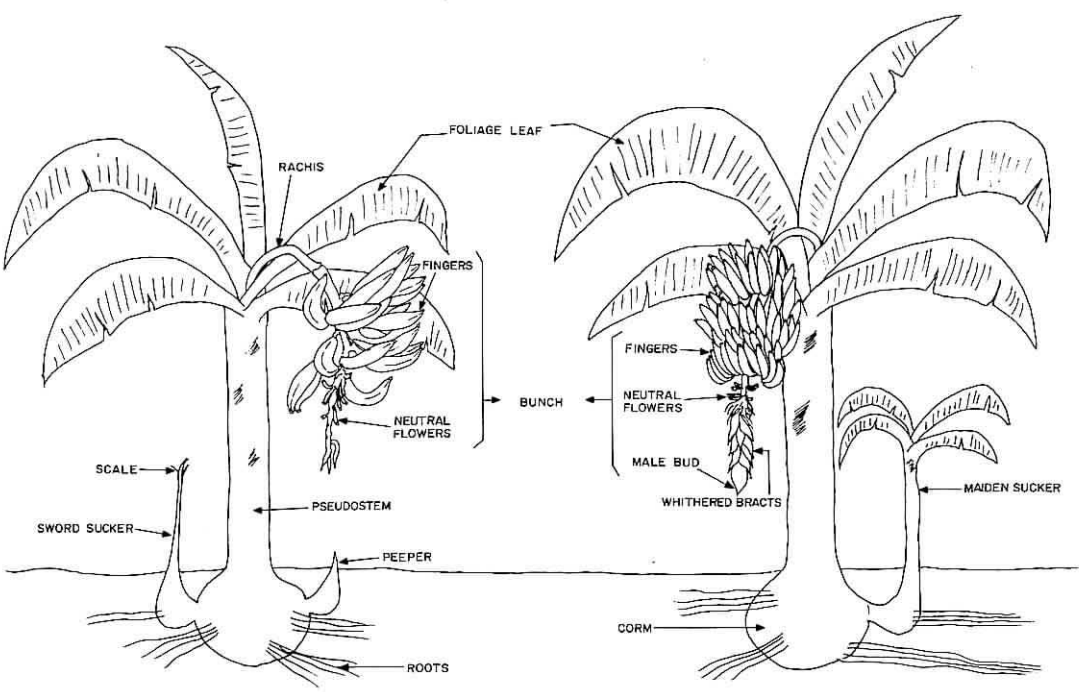
plantains are like giant herbs and not like trees. The leaf sheaths render support to the rachis of the mother plant. Young suckers (shoots from the main plant which can develop into bearing plants) have narrow, lanceolated leaves which are called scales and are easily distinguishable from the large foliage leaves.

(c) Underground corm with suckers and roots. The corm, sometimes wrongly called a bulb, is the true stem of the plant.

Numerous roots emerge from the corm, most of which grow horizontally at a depth of 0 to 15 cm. Roots are whitish if young and healthy and become brown with age. If infested by nematodes, they become brown or even black and/or show protuberances.

The growing tip (or meristem) at the top of the corm continuously forms new leaves and later becomes the inflorescence. The corm produces many branches, called suckers, and the whole unit is often referred to as the "mat" or "stool". After the plant crop has been harvested, the mother plant is cut down and the suckers are thinned. Although all suckers are followers or daughter plants, the

Figure 2
Schematic view of bearing False Horn plantain (left) and French plantain (right)



cultivator selects one (the ratoon) to continue the next cycle of production. The second harvest from the plantain mat is called the first ratoon crop. The third harvest is the second ratoon crop, and so on.

2. Cultivars

At least 116 plantain cultivars have been identified in West and Central Africa. Plant size and bunch type are the most important characteristics for production purposes.

Plant size depends on the number of leaves produced before flowering:

giant more than 38 foliage leaves;
medium between 32 and 38 foliage leaves;
small fewer than 32 foliage leaves.

When the plantains flower, leaf production has ended.

Bunch morphology provides another method of classification (figure 2):

French plantains: bunch is complete at maturity. Many hands consist of numerous, rather small fingers followed by the bunch axis covered with neutral flowers and male flowers; the male bud is large and persistent.

False Horn plantains: bunch is incomplete with no male bud at maturity. Hands consist of large fingers followed by a few neutral flowers.

Horn plantains: bunch is incomplete at maturity. Hands are few in number and consist of a few but very large fingers. There are no neutral flowers or male bud; a tail or a deformed glomerule terminates the bunch axis. The Horn plantain resembles the False Horn but it has no neutral flowers and has larger fingers.

Figure 3
Base of a plantain with one sword sucker (tallest sucker) and four peepers

3. Sources of planting material

Several types of conventional planting material exist:

peeper: a small sucker emerging from the soil (figure 3);
sword sucker: a large sucker with lanceolated leaves (figure 3), the best conventional planting material;
maiden sucker: a large sucker with foliage leaves;
bits: pieces of a chopped corm.

A new and most promising planting material consists of in vitro plants which are small maiden suckers produced from meristem culture (figure 4).

Figure 4
In vitro produced material ready for planting

Planting material can be collected from:
(a) An existing field, preferably an old field which is becoming unproductive. Otherwise damage to the roots may be

Figure 5
Rapid sucker multiplication through the technique of decapitation (a, b) and false decapitation (c, d)

a

b

caused when the suckers are being dug out and many mother plants may later tip over.

(b) A multiplication plot, which is planted only for the production of suckers and not to produce bunches. Plant density (2 m x 2 m) is much higher than in production fields and suckers are obtained by either decapitation or false decapitation. Both methods consist of removing the growing point (figure 5). In the first method, the pseudostem is removed to get to the growing point. Only a small hole or window is cut for the second method. The foliage can remain active for up to 3 months after the removal of the meristem by the second method.

(c) A tissue culture laboratory, where in vitro plants which look like small maiden suckers are produced from meristems. In vitro plants are healthy, vigorous, free from pests and diseases (figure 4) and have a great future.

Figure 6
Plantain field mulched with elephant grass

4. Climate

Plantains, like other bananas, require a hot and humid environment. Ideally, the average air temperature should be about 30°C and rainfall at least 100 mm per month. Rainfall should be well distributed throughout the year and dry seasons should be as short as possible. Irrigation is not suitable nor economically worthwhile for plantains grown by the family farmer, but may become necessary when larger fields are cultivated in areas with a long dry season.

5. Mulch

Organic matter is essential for plantain cultivation (figure 6). External sources of mulch can consist of elephant grass (*Pennisetum purpureum*), which is rich in potassium, or

c

d

cassava peelings, wood shavings, palm bunch refuse, dried weeds, kitchen refuse, and so on. Collecting and transporting mulch are expensive in time and labor. The most convenient source consists of plants growing inside the plantain fields if they produce a great deal of organic matter without competing with the plantains.

Suitable mulch material can be obtained from trees which were slashed when the fields were cleared and which are growing again (figure 7); or from a deep-rooted legume shrub called *Flemingia congesta* or *F. macrophylla* (figure 8). *F. congesta* is seed drilled in the middle of the 3 m plantain alley. It can be difficult to establish, but from the second year onwards it grows vigorously. It can reach a height of approximately 2.5 to 3 m if left unpruned, but in the field it is cut back 4 times a year to a height of about 1.5 m

Figure 7
Trees regrowing between the plantains provide mulch

Figure 8
***Flemingia congesta* as an alley crop**

(figure 8). The prunings are spread over the soil. *Flemingia* is not fertilized as it benefits from fixed nitrogen and leached fertilizers applied to the plantains. Grass growing between the plantains is not suitable as a mulch source because it competes with the plantains.

6. Fertilizer

The plantain crop always benefits from the use of fertilizer (table 1). The yield from fertilized plants can be up to 10 times higher than that from unfertilized plants. The amount of fertilizer needed depends on soil fertility and soil type. General recommendations cannot be made as these should be based on soil or leaf analysis and the results of fertilizer experiments. Since potassium and nitrogen are easily leached, they should always be applied at regular intervals (split applications) during the growing (rainy) season. Other important nutrients are phosphate, calcium and magnesium which are provided in one application. In some exceptional cases, micro-nutrients (for example, zinc or sulfur) have to be applied.

Table 1
Yield of the plant crop and first ratoon of a medium False Horn plantain under four different fertility conditions

(in tons per hectare)

	Control	Fertilizer[a]	Mulch[b]	Mulch + fertilizer
Plant crop	0.6	11.9	14.1	18.8
First ratoon	0.6	2.8	10.2	10.4

a 550 kg of potassium oxide and 300 kg of nitrogen per hectare
b 80 tons per hectare of *Pennisetum purpureum* (elephant grass)

b

a

7. Weed control

Weeds can be hand-pulled or chemically controlled. Paraquat and simazine are appropriate herbicides since they control the weeds without affecting the plantains, unless leaves are accidentally sprayed. Glyphosate, diuron and gramuron are not recommended as they can be phytotoxic to plantains.

8. Disease and pest control

Black sigatoka is the major disease attacking plantains; nematodes and stemborers are the major pests.

Black sigatoka is a leaf spot disease (figure 9a-d) caused by the fungus *Mycosphaerella fijiensis*. All known plantain cultivars are susceptible to this wind-borne fungus. Leaves first show yellow spots (9a,b) which later turn brown and black (9b). Ultimately the leaf tissue becomes necrotic (9c) and dies. In this way entire leaves become nonfunctional and in many cases, bearing plants are left with hardly any

Figure 9
Declining stages of black sigatoka symptoms (counter clockwise, from top right)

c

d

Figure 10
Fougamou 1 (cooking banana)

green leaves at maturity (9d). Photosynthesis is reduced and small bunches (sometimes with undeveloped fingers) are produced. Yield losses are estimated at between 30 and 50 percent.

Black sigatoka can be controlled with aerial applications of fungicides belonging to the groups of the benomyl, benzimidazoles, chlorothalonils, dithiocarbamates, flusilazoles, imazaliles, imidazoles, methylthiophanates, nuarimols, prochloraz, propiconazoles, triazoles and tridemorph, or soil-applied fungicides such as triadimefon and triadimenol. In any case, at least two types of fungicide should be used alternately to prevent the fungus from developing resistance to the active ingredient.

Plantain cultivars resistant to black sigatoka provide the only effective means of control since the fungicides are very expensive and can pose health hazards when applied in backyards. Breeding for resistance began at the Onne station of the International Institute of Tropical Agriculture (IITA) in Nigeria during 1988. For the time being, cooking bananas ("Fougamou 1", "Bom", "Gia Hui", "Foulah 4" and "Nzizi") are available from IITA (figure 10) as a substitute for plantain. These varieties are resistant to black sigatoka and can be prepared and consumed in the same ways as plantains.

Nematodes are minute worms which live in the soil and infest plant roots. Several types of nematodes can extensively damage the plantain root system if the land was previously cropped with plantains or if they were introduced with infected planting material (figure 11). Nematodes impair the transport of nutrients and water to the main stem, causing a reduction in yield and weakening of the plant. As

Figure 11
Nematode damage

a result, many plants may be lost through tip-over whenever winds become strong.

Nematodes can be controlled by applying nematicides in a circle, 25 cm in diameter, around the plant.

Some of these nematicides are:

Nematicides	Rate per plant (grams)	No. of applications per year
isazophos	2.5 a.i.	3
carbofuran	4.0 a.i.	3
ethoprophos	4.5 a.i.	3
phenamiphos	3.0 a.i.	3

a.i. = active ingredient

As carbofuran is effectively degraded by microorganisms, it should be used alternately with other nematicides.

The stemborer or banana weevil *Cosmopolites sordidus* (figure 12) lays its eggs near the corm of the main plant. The larvae attack the underground part of the plant, feeding on

Figure 12
The banana weevil *Cosmopolites sordidus:* larva (top) and adult (bottom)

Figure 13
Stemborer damage to plantain corm

the corm and boring channels in it (figure 13). Plants become very weak, especially during the dry season, and tip over. Yield can be drastically reduced.

Stemborers can be controlled by leaving the land under fallow, by the application of coffee husks and by insecticides.

Insecticides	Rate per plant (grams)		No. of applications per year
HCH (50%)	40	c.p.	3
chlordecone	1	a.i.	2
isofenphos	1.2	a.i.	3
aldicarbe	1.5	a.i.	3
carbofuran	2	a.i.	3

c.p. = commercial product
a.i. = active ingredient

The cost of insecticides should determine whether they should be used. The use of traps provides an alternative method for controlling banana weevils which is cheap but time-consuming and not as effective as the use of insecticides. Traps are made by cutting pseudostems in half longitudinally and laying the pieces cut side down on the soil near the plantains (figure 14). One trap for every 20 to 30 plants is the current practice. Traps should be inspected daily early in the morning. The adult black weevils are then retrieved from between the soil and the cut surface of the pseudostem and killed. Traps remain effective for about 1 or 2 weeks and are renewed at harvest when an ample supply of pieces of pseudostem is available.

Figure 14
Stemborer trap from a piece of pseudostem

9. Fallow

A field that becomes unproductive should be left fallow when the plantain mats have been destroyed. Good results can be obtained with the use of kerosene, glyphosate or 2-4 D but the plantain mats can only be completely destroyed by hand. This ensures that no live material remains to harbor pests and reinfect the field.

To restore fertility, the organic matter in the soil should be raised as high as possible during the fallow period by planting an improved fallow (for example, a leguminous cover crop). Otherwise the fallow crop can consist of trees which were cut down at planting time and are growing back or of *Flemingia congesta* which was grown between the plantain rows as a source of mulch. In addition to restoring fertility, the fallow crop should by itself completely eliminate all kinds of weeds, especially grasses. A grass fallow is not suitable as grass easily grows again and becomes a noxious weed.

PART TWO How to grow plantains

Most plantains produced in West Africa come from compound gardens or backyards inside villages (figure 15). Backyard soil is very rich in organic matter and nutrients from household refuse which is dumped there. Such gardens are permanently in use for plantains which grow there luxuriantly, become very large and produce heavy bunches. They grow in groups or clusters as each bearing plant produces many suckers which are not pruned out. Human activity is limited to manuring, propping and harvesting.

Since the demand and thus the price for this crop are continuously increasing, many farmers want to grow more plantains in order to raise their income. However, backyards cannot be readily extended since they are enclosed by houses or fences. The only way, therefore, to expand production is to grow plantains in fields at some distance from the village. In most cases such field-grown plantains are very poorly maintained. The result is a very modest yield from the first year onwards. Different methods of cultivation

Figure 15
Compound garden with plantains

should accompany the change in site to achieve and sustain high-level yields for several years.

1. Selecting the site

The site should be easily accessible, especially if the establishment of a large field is being planned. It should be well drained but not too steeply sloped. Plantain cultivation is impossible if the land becomes flooded from time to time, or has a water table at a depth of only 50 cm or less. The soil should be rich in organic matter (black soil). Hence fields in a long natural fallow, under an improved established fallow or with a lot of mulch are recommended.

2. Preparing the field

Fields are to be prepared with minimum disturbance to the soil (no-tillage farming). In consequence, manual clearing should be preferred to mechanical deforestation because bulldozers always remove topsoil with the important organic matter and compact the remaining soil. When an old natural fallow is cleared, the debris from the forest should be burned if plantain cultivation is planned for 1 or 2 cycles only. If perennial cultivation is being considered, planting should be done through the mulch (figure 16). Young fallows of about 3 to 5 years or improved legume fallows should be simply slashed and left without being burned. Trees must be cut but the stumps are not to be removed, and the trees should be left to grow again (figure 7). They can be pruned only when they start to obstruct field activities or shade the plantains. Once the fallow crop is slashed, the field is ready for pegging. Drains should be dug if some spots in the field tend to waterlog after heavy rains.

Figure 16
Plantains growing on cleared land which was not burned

a

Figure 17
French (a), False Horn (b) and Horn (c) plantains

3. Spacing

The recommended spacing is 3 m between the plantain rows and 2 m within the row (in other words, 3 m x 2 m). An alternative is 2.5 m x 2.5 m. If spaced 3 m x 2 m, 1 hectare should contain 1667 plants, but with a spacing of 2.5 m x 2.5 m, it should contain 1600 plants. Rows should be straight in flat fields to give plants the maximum amount of sunlight. However, on sloping land, rows should follow the contour lines in order to decrease soil erosion.

4. Selecting cultivars

For field cultivation, medium plantains should be preferred to giant ones even though giant plantains produce heavier bunches. Giant plantains take longer to produce and are more likely to be damaged by strong winds because of their size.

The decision whether to grow a French (figure 17a) or a False Horn (figure 17b) plantain cultivar should depend on which type the consumers prefer. Horn plantains (figure 17c) should never be cultivated as their yield is very low.

b

c

5. Preparing suckers

Suckers are separated from their mother plant with a spade or machete. The sucker corm must not be damaged or chipped. Consequently the corm should be carefully peeled with a machete. The pseudostem of the suckers should be cut off a few centimeters above the corm (figure 18). Peeling of the corm delays the development of nematode infestation, while cutting of the pseudostem reduces bulkiness and improves early growth of the newly planted sucker.

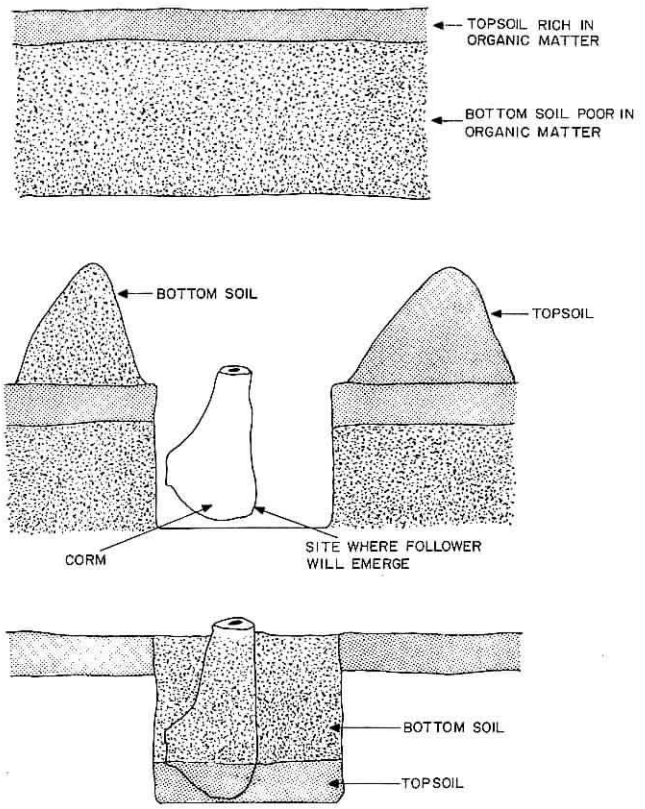
Figure 18
An unprepared sucker (left) and peeled suckers (right) ready for planting

The peeling process is just like that for cassava. A freshly peeled healthy corm ought to look white, but corms infected by stemborers and nematodes show brown and black spots which have to be removed until only white tissue remains. If the infestation is severe, with many brown and black spots, the sucker should be destroyed. Sucker preparation (peeling) is carried out in the field where the planting material is collected. This is to avoid contamination of the new field with roots infested with nematodes or corms with stemborers. Prepared corms are transported to their destination where they are left to dry for a few days (not in the sun). Suckers have to be planted within 1 week. Storage of suckers for more than 2 weeks will adversely affect future yields.

6. Planting

Suckers are planted immediately after field preparation. Plant holes are prepared with a minimum size of about 30 cm x 30 cm x 30 cm. Care should be taken to separate the topsoil from bottom soil. The sucker is placed in the hole and its corm is covered, first with the topsoil and then with the bottom soil (figure 19). In the plant hole, the side of the sucker corm which was formerly attached to the corm of its mother plant is placed against the wall of the hole. The opposite side of the sucker corm is placed towards the middle of the plant hole, where the soil is loose (figure 19). The best sucker (the future ratoon) will emerge at the side opposite to where the planted sucker was previously attached to the mother plant. If the land is sloping, the sucker should be so oriented that its follower will emerge against the slope. That will delay the development of the so-called high

Figure 19
Arrangement of top and bottom soil when a sucker is planted



mat when the ratoon crop grows out of the soil and exposes the corm.

7. Choosing the time to plant

Plantains can be planted throughout the rainy season. However, they should grow vigorously and without stress during the first 3 to 4 months after planting, and therefore they should not be planted during the last months of the rainy season. Planting with the first rains seems agronomically sound but not financially advantageous. Most farmers will plant at the onset of the rains, causing the market to be flooded with bunches 9 to 12 months after planting, when prices will be very low. Planting in the middle of the rainy season is a better proposition as plantains will then be produced off-season and get high prices.

8. Mulching

Organic matter is essential for plantain cultivation (table 1, page 6) if the field is to be very productive for a long time. A high level of organic matter in the soil is beneficial because

it stimulates root development, improves soil drainage, decreases soil temperature fluctuations, and increases soil porosity and biological life.

Organic matter decays under the influence of microorganisms in the soil, heavy rainfall and high soil temperature. The amount of organic matter will gradually decrease once the field has been cleared and cause a decrease in yield. Therefore newly established plantains which receive only fertilizer will produce a high yield only in the first year. In the second year the yield will drop because the organic matter will have decomposed (figure 20 and table 1). To compensate for this continuous decrease in the amount of organic matter, the field needs mulch from plants and/or manure from animals. There are many sources of mulch. It can be either carried into the field or produced between the plants; but to be effective, it should cover the soil completely (figure 21). Once the field is mulched, weeds are controlled and the topsoil is protected against heavy rainfall and intense sunshine. Poultry, pigs and cows produce suitable manure which is applied only at the base of the mat.

9. Fertilizing

To produce a heavy bunch, plantains always need some extra nutrients. These can be applied in the form either of inorganic fertilizers or organic fertilizers (mulch, manure or ash from wood fires). Inorganic fertilizers have the advantages of easy handling and concentrated nutrients. Organic fertilizers are very bulky, yet they manifest many important characteristics. They improve soil moisture retention, weed and erosion control, soil porosity and biological activity.

Figure 20
Six-month-old plantain field showing deficiencies due to use of fertilizer without mulch

Figure 21
Six-month-old plantain field, showing beneficial effects of mulching

The application of fertilizer should start 1 month after planting of plantains or with the first rains in an already existing field. The fertilizer is applied around the main plant in a circle about 50 cm in diameter. Fertilizer is not worked into the soil as that causes extensive damage to the superficial root system. No fertilizer is applied in the dry season.

10. Controlling weeds

Plantains should always be weed-free. Weed control starts during field preparation. Weeds are initially controlled about every 6 to 8 weeks; but when the plantain canopy closes, about 5 to 6 months after planting, weed infestation declines due to shading. Any plant with a superficial root system should be considered a weed and therefore eliminated. Grasses or herbs are the most pernicious weeds because they derive their nutrients from the same level of the soil as the plantains. Tree seedlings are not considered to be weeds.

Weeds can be controlled through mulching, chemically or manually. Mulching is the most efficient means, because a mulch layer can impede or prevent weed growth. Chemical control is expensive and in some circumstances also dangerous. Manual weeding is not recommended, although the weeds are thereby effectively controlled, because slashing or hoe weeding inevitably damages the plantain root system. However, sometimes manual weeding is the only possible method.

11. Intercropping

Plantain fields are arranged in rows spaced 3 m x 2 m. As the canopy closes only some 5 to 6 months after planting, a fair amount of inter-row space remains unexploited during the first months. This space can be used for plants which have a short life cycle and which do not compete with plantains. Groundnut, yam, cocoyam (figure 22) and maize are suitable intercrops although maize effectively delays the plantain harvest by about 2 months. Cassava and cowpea are not suitable, because their yields are reduced under the shade of plantain rows. Plantains can be used as a shade crop for young cocoa and coffee plants.

Figure 22
Plantain intercropped with cocoyam

12. Propping

The heavy weight of the plantain bunch bends all bearing plants and can cause doubling (pseudostem breaks), snap-off (corm breaks, leaving a part in the ground) or uprooting, also called tip-over (the entire corm with roots comes out of the ground). Plants are generally weak during the dry season and strong winds, nematodes and stemborers also increase the rate of loss. For these reasons, bearing plants always need support from 1 or 2 wooden props, usually made of bamboo (figure 23). If a piece of bamboo is used, the support is placed alongside the bearing plant and the top of the plant is tied to the bamboo. A lateral branch at the top of the bamboo prop sometimes forms a natural fork which can be used to support the plantain without being tied to it. When 2 pieces of bamboo are used, the bunch and not the plant is supported in the first place. The bamboo props are crossed and form a fork. This fork is tied together with a rope and placed just underneath the bunch.

Figure 23
Supporting a bearing plantain

13. Harvesting

The bearing plant is cut and the bunch, 3 to 4 months old, is harvested when 1 or 2 fingertips of the first hand start yellowing. The bunch usually then ripens within a week. Care has to be taken that the bunch does not drop on the ground when the main plant is cut. The whole of the pseudostem and foliage of the main plant is then chopped (figure 24) and spread over the soil as a mulch for the ratoon crop. If this is not done, weevils may live and multiply on the intact pseudostem.

14. Thinning

Unlike those of most other bananas, plantain suckers develop very slowly. After harvest, all suckers start to grow at

Figure 24
Chopped plantain plant after harvest with one sucker remaining

the same time and most have to be eliminated to stop competition (figure 25). The tallest is left to guarantee the follow up and maintain the density. Thinning usually has to be repeated a month later, as new suckers will have emerged by that time. Suckers are thinned with a machete. The sucker pseudostem is cut off near its corm and the point of the machete is twisted in the growing tip, thus killing it.

15. Controlling high mat

After production of several ratoon crops, the upper surface of corms in aging plantain fields can be seen above soil level. The exposure of the corms, which is called high mat (figure 26), is believed to have several causes. The nature of ratooning in plantains seems to be particularly important. High mat exposes the roots which dry out. The plants become weak and tip over easily because they are no longer firmly based in the soil. Earthing up (adding soil around the plant) does not help much. However, mulch protects the roots which would otherwise dry out and improves the ramification and stability of the plants.

16. Managing the fallow period

A field which becomes unproductive should be left fallow. If plantains are to be planted again after a fallow period, the following points should be considered.

- At the beginning of the fallow, all plantain mats should be entirely destroyed. Otherwise, remaining plants could maintain nematode and stemborer populations which would readily infest newly planted plantains after the fallow period.

Figure 25
Thinning of plantain mat

Figure 26
High mat

- Only manual destruction guarantees the complete elimination of the existing plantain mats.

- The level of organic matter in the soil should be raised as high as possible during the fallow period in order to restore fertility. This can be done by allowing trees to regrow and/or by planting a legume cover crop.

- The fallow period should last at least 2 to 3 years.

GLOSSARY

°C: degrees Celsius, Centigrade
2,4 D: a herbicide

aldicarbe: an insecticide
anchorage: stability of plantains in the soil
backyard: compound garden
banana weevil: an insect that damages the plantain corm
benomyl: a fungicide
benzimidazole: a fungicide
bits: pieces of chopped corm used in planting
black sigatoka: severe leaf spot disease of plantains and bananas
"Bom": a variety of cooking banana resistant to black sigatoka
bottom soil: soil from the bottom of a hole dug for planting
bract: a purple modified leaf covering a flower cluster
breeding: plant improvement
canopy: cover formed by leaves
carbofuran: a nematicide and insecticide
chlordecone: an insecticide
chlorothalonil: a fungicide
cm: centimeter
contour line: a line connecting the points on a land surface that have the same elevation
cooking bananas: starchy bananas which have to be cooked
corm: the (underground) stem of a plantain or banana which produces suckers and roots
***Cosmopolites sordidus*:** see banana weevil
cultivar: cultivated variety
daughter plant: sucker succeeding the bearing plant
decapitation: the process of eliminating the growing tip after cutting the pseudostem; used in sucker multiplication
dithiocarbamate: a fungicide
diuron: a herbicide
doubling: breaking of the pseudostem
drainage: the gradual disappearance of water in the soil
earthing up: heaping soil in mounds at the base of the main plant
ethoprophos: a nematicide
fallow: previously cultivated land that is allowed to lie idle, usually in order to recover its fertility
false decapitation: the process of eliminating the growing tip after an opening (a window) has been made in the base of the pseudostem; used in sucker multiplication. See also decapitation
False Horn plantains: plantains with an incomplete inflorescence at maturity; hands consisting of large fingers followed by few hermaphrodite flowers, no male bud at maturity
female flowers: those flowers on the bunch whose ovaries develop into fruit
fertilizer: a chemical mixture used to supply nutrients to the soil
finger: a single plantain or banana fruit
***Flemingia congesta* (*F. macrophylla*):** a legume shrub used as an alley crop in plantain fields; cut regularly to supply mulch
flowering: producing flowers
flusilazole: a fungicide
foliage leaves: the big leaves of a plantain or banana
follower: sucker, daughter plant succeeding the bearing plant
"Fougamou 1", "Foulah 4": varieties of cooking banana resistant to black sigatoka
French plantains: plantains with a complete inflorescence at maturity. This type has many hands consisting of many, rather small fruits followed by the inflorescence axis covered with persisting hermaphrodite flowers and male flowers; the male bud is large and persistent
fungicide: chemical used to kill fungi

fungus: any of a major group of saprophytic and parasitic lower plants that lack chlorophyll and include molds, rusts and mushrooms, among others

g: gram

"Gia Hui": a variety of cooking banana resistant to black sigatoka

giant plantains: tall plantains which produce more than 38 foliage leaves before flowering

glomerule: protuberance on the rachis of a bunch

glyphosate: a herbicide

gramuron: a herbicide

hand: a cluster of fingers borne on the same glomerule

HCH: an insecticide

hectare: area of land 100 m by 100 m

herbicide: chemical used in killing weeds

hermaphrodite flowers: intermediate or neutral flowers which persist on the bunch but do not develop into fruit

high mat: the upper portion of the corm grows out of the soil, exposing a considerable area of root-bearing tissue

Horn plantains: plantains with an incomplete inflorescence at maturity. This type has few hands consisting of few but very large fingers, no hermaphrodite flowers and no male bud

imazalil: a fungicide

imidazole: a fungicide

inflorescence: a floral axis with clusters of flowers

insecticide: chemical used in killing insects

intermediate flowers: see hermaphrodite flowers

in vitro plant: plant produced from a meristem and cultivated temporarily in a laboratory

isazophos: a nematicide

isofenphos: an insecticide

lanceolated: tapering to a point at the top and sometimes at the base

leaf sheath: the lower part of the leaf which forms the pseudostem of the plantain plant

legume: a plant which fixes nitrogen from the atmosphere by interaction with bacteria

m: meter

maiden sucker: a large sucker with foliage leaves

male bud: the big purple terminal protuberance of the plantain bunch

male flowers: flowers which are found in the male bud

manure: organic mulch from animal origin; e.g. poultry manure

mat: corm with suckers; stool

meristem: growing tip which is found on the corm

medium plantains: plantains producing between 32 and 38 foliage leaves before flowering

methylthiophanate: a fungicide

micronutrient: nutrient needed in very small amounts for good plant development

microorganism: an organism of microscopic size; e.g. fungus, bacterium

mm: millimeter

morphology: form, structure

mother plant: a plantain plant with a bunch

mulch: organic matter of plant origin used to cover soil and improve fertility

Musa: genus name of bananas which includes dessert bananas, cooking bananas and plantains, and their wild relatives.

***Mycosphaerella fijiensis*:** wind-borne fungus causing black sigatoka disease

nematicide: chemical used in killing nematodes

nematode: minute parasitic worm which damages plant roots

neutral flowers: see hermaphrodite flowers

no-till farming: farming without soil disturbance

nuarimol: a fungicide

"Nzizi": a variety of cooking banana resistant to black sigatoka

ovary: the basal portion of the flower which develops into a fruit in female flowers, but not in hermaphrodite and male flowers

paraquat: a herbicide

peduncle: see rachis

peeper: a small sucker emerging from the soil

pegging: using pegs to mark a field or planting holes

***Pennisetum purpureum*:** elephant grass
phenamiphos: a nematicide
photosynthesis: synthesis of chemical compounds with the aid of light
phytotoxic: poisonous to plants
plant crop: the crop which is harvested from the planted sucker
porous: having small holes through which liquids can pass
prochloraz: a fungicide
propiconazole: a fungicide
propping: the action of supporting bearing plants
protuberance: a lump or projection
pseudostem: false stem consisting of enclasping leaf sheaths
pulp: the edible part of the fruit
rachis: the peduncle, a stalk which bears fruit
ramification: branching
ratoon: the sucker succeeding the harvested mother plant
scales: narrow leaves which are produced by peepers and sword suckers
simazine: a herbicide
small plantains: plantains producing fewer than 32 foliage leaves before flowering
snap-off: corm breaks, leaving a part in the ground
split application: the application of identical amounts of a substance (e.g. fertilizer) at regular intervals
stemborer: see banana weevil
stool: see mat
sucker: a shoot from the main plant which can develop into a bearing plant
sword sucker: a large peeper with lanceolated leaves
thinning: the process of eliminating all but one sucker to avoid competition
tip-over: entire corm with the roots comes out of the ground
ton: 1000 kilograms
topsoil: soil at the top or on the surface of the field which is usually darker and richer in nutrients than the bottom soil underneath it
triadimefon: a fungicide
triadimenol: a fungicide
triazole: a fungicide
tridemorph: a fungicide
uprooting: see tip-over
waterlogging: when water remains on the field after rain; this is caused by bad drainage

About IITA

The goal of the International Institute of Tropical Agriculture (IITA) is to increase the production of key food crops and to develop sustainable agricultural systems that can replace bush fallow, or slash-and-burn cultivation in the humid and subhumid tropics. Crop improvement programs focus on cassava, maize, plantain, cowpea, soybean and yam. Research findings are shared through international cooperation programs, which include training, information, and germplasm exchange activities.

IITA was founded in 1967. The Federal Government of Nigeria provided a land grant of 1,000 hectares at Ibadan for a headquarters and experimental farm site, and the Rockefeller and Ford foundations provided financial support. IITA is governed by an international Board of Trustees. The staff includes around 180 scientists and professional staff from about 40 countries, who work at the Ibadan campus and on substations and outreach programs in many countries of tropical Africa.

IITA is one of 13 nonprofit, international agricultural research centers supported by the Consultative Group on International Agricultural Research (CGIAR). Established in 1971, CGIAR is an association of about 50 countries, international and regional organizations, and private foundations. The World Bank, the Food and Agriculture Organization of the United Nations (FAO), and the United Nations Development Programme (UNDP) are cosponsors of this effort.

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